FISHERY MANAGEMENT INVESTIGATIONS

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Clearwater Region 2009 Annual Fishery Management Report

Mountain Lakes Investigations

Mountain Lakes Monitoring In Consideration Of Amphibian Risk Assessment In North Central Idaho

ABSTRACT

In 2009, personnel completed surveys on twelve lakes within five HUC 5 watersheds in the Nez Perce and Clearwater National Forests. The five HUC 5 watersheds included Baragmin Creek (elevated amphibian risk category in the Nez Perce National Forest), North Fork Moose Creek (low amphibian risk category in the Nez Perce National Forest), Running Creek (moderate amphibian risk category in the Nez Perce National Forest), Storm Creek (low amphibian risk category in the Clearwater National Forest), and Warm Springs Creek (moderate amphibian risk category in the Clearwater National Forest). In the Bargamin Creek watershed one lake was surveyed. Visual encounter surveys documented Columbia spotted frogs *Rana luteiventris* and Idaho giant salamanders *Dicamptodon aterrimus* in Three Prong Lake. Changes in amphibian distribution cannot be determined as historical inventory information is lacking for this lake. One lake was surveyed in the North Fork Moose Creek HUC 5 watershed. Visual encounter surveys documented both Columbia spotted frogs and long-toed salamanders *Ambystoma macrodactylum* in Section 28 Lake. Columbia spotted frog and long-toed salamander observations represent no change from historical inventory information for this lake. One lake was surveyed in the Running Creek HUC 5 watershed. Eagle Creek Lake was no longer a standing body of water in 2009. Surveys of five lakes were completed in the Storm Creek watershed. Only Columbia spotted frogs were observed in these five lakes surveyed. Past inventories (1991, 1996, and 1997) documented Columbia spotted frogs in five of the lakes and long-toed salamanders in three of the lakes. Rainbow trout *Oncorynchus mykiss* were present in one of the lakes in both 2009 and past surveys in the Storm Creek watershed. Surveys of four lakes were completed in the Warm Springs Creek watershed. Columbia spotted frogs were observed in four lakes surveyed in 2009 and long-toed salamanders were observed in one of these lakes. Past inventories (1995 and 1996) documented Columbia spotted frogs in four of the lakes and long-toed salamanders in two of the lakes. Westslope cutthroat *O. clarkii lewisi* were present in two of the lakes in both 2009 and past surveys in the Warm Springs Creek watershed. For those lakes surveyed from 2006 to 2009, a general decline in amphibian presence was observed in both lakes with and without fish when compared to historic surveys. These declines were most prevalent for long-toed salamander.

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INTRODUCTION

A 20-year study was designed in 2006 to evaluate long-term trends in amphibian populations within high mountain lakes in the Clearwater Region and to determine the extent fish stocking was a threat to their persistence. Mountain lake surveys prior to 2006 provide baseline information on amphibian and fish abundance and distribution and were utilized to develop an amphibian risk assessment based on the amount of fishless lakes and ponds within HUC 5 watersheds throughout the Clearwater Region. This year was the fourth year of the long-term monitoring project, thus temporal and spatial patterns in amphibian occurrences cannot yet be determined because multiple cycles of sampling are necessary.

Amphibian population reduction and species extinction has given urgency to amphibian conservation, inventory efforts to determine baseline data, and monitoring to determine trends in amphibian populations (Houlahan et al. 2000; Stuart et al. 2004; Beebee and Griffiths 2005; Orizaola and Brana 2006). Potential factors in amphibian population decline are numerous and include: habitat modification/fragmentation, introduction of predators/competitors, increased UV-B radiation, changes in precipitation/snowpack and pathogen infection (Alford and Richards 1999; Corn 2000; Pilliod and Peterson 2000; Marsh and Trenham 2001). Throughout the North Central Mountains of Idaho, direct (predation) and indirect (resource competition, habitat exclusion, and population fragmentation) impacts on amphibian populations from introductions of trout into historically fishless lakes are a cause for concern (Petranka 1983; Semlitsch 1988; Bradford 1989; Figiel and Semlitsch 1990; Bradford et al. 1993; Brönmark and Edenhamn 1994; Gulve 1994; Brãna et al. 1996; Tyler et al 1998). Trout have been stocked into high mountain lakes to provide recreational opportunities to backcountry visitors. According to historical stocking records some lakes in North Central Idaho were stocked as early as the 1930s (Murphy 2002). As much as 95% of previously and/or currently stocked high mountain lakes throughout the western United States that were once fishless, now contain fish through regular stocking efforts or self-sustaining populations from legacy stocking efforts (Bahls 1992). Murphy (2002) estimated that 96% of lakes within the Clearwater National Forest were historically fishless due to steep headwater topography.

Mountain lake ecosystems in North Central Idaho predominantly contain amphibian populations of long-toed salamanders *Ambystoma macrodactylum* (Mole Salamander) and Columbia spotted frogs *Rana luteiventris* (True Frog), although viable populations of Idaho giant salamanders *Dicamptodon aterrimus* (Pacific Mole Salamander), western toads *Bufo boreas* (True Toad), and Rocky Mountain tailed frogs *Ascaphus montanus* (Bell Toad) persist. Common reptiles found at these mountain lakes may also include common garter snakes *Thamnophis sirtalis* and western terrestrial garter snakes *T. elegans*, both of which were historically (before fish introductions) the main amphibian predators (Murphy 2002). The Idaho Department of Fish and Game (IDFG) Clearwater Region contains 711 mountain lakes located within the Bitterroot National Forest, Clearwater National Forest, and Nez Perce National Forest. These three national forests encompass in entirety or portions of four wilderness areas (the Frank Church, Gospel Hump, Hells Canyon, and Selway Bitterroot) and one Pioneer Area (the Mallard Larkins). Approximately 400 high mountain lakes were previously inventoried within these management areas through cooperation between the IDFG and United States Forest Service (USFS).

Murphy (2002) found that Columbia spotted frog occurrence (and breeding occurrence) in this area was not significantly different in lakes with or without fish after accounting for habitat effects (Columbia spotted frogs were positively associated with increasing amounts of sedge meadow perimeter and silt/organic substrate). However, Columbia spotted frog abundance for all life-stages were significantly lower in lakes with fish than without fish (Murphy 2002). Long-toed salamander larvae and/or breeding adult occurrence and abundance (adults are typically terrestrial except to breed) was significantly less common in lakes with fish then lakes without fish (Murphy 2002). However, where native (not stocked) westslope cutthroat existed in lakes the impact on long-toed salamanders was not as severe as compared to lakes that were historically fishless and later stocked with introduced western trout (Murphy 2002). Other studies have examined relationships between introduced trout and salamanders. Direct negative impacts by fish on amphibian populations have been mostly attributed to larval predation and the cessation of lake use as breeding sites by terrestrial adults (indirect impact) (Kats et al. 1993; Figiel and Semlitsch 1990; Bradford et al. 1993; Knapp 1996; Pilliod 1996; Graham and Powell 1999; Murphy 2002).

Introduced fish populations may also indirectly impact amphibian gene flow, recolonization, and subsequent persistence. The degree of gene flow in mountain lake amphibians likely relies on connectivity between higher and lower elevations subpopulations (with low gene flow) and to some degree the closet neighbor that is not necessarily within the same wet stream migration corridor when overland dispersal is not drastically limited by headwater topography, precipitation, and or canopy cover (Murphy 2002). Tallmon et al. (2000) suggests that long-toed salamanders within North Central Idaho are panmictic (randomly interbreeding populations) with high levels of within population variation providing evidence that populations are not evolving in complete isolation. Amphibian populations or demes in these headwater areas likely never evolved with native fish and may lack the appropriate defensive, behavioral, or chemical responses to coexist with introduced fish populations (Kats et al. 1988).

Murphy (2002) also found that certain species of introduced trout tend to have a greater impact on amphibian occupancy than others. Westslope cutthroat *Oncorhynchus clarkii lewisi*, rainbow trout *O. mykiss*, rainbow x cutthroat hybrids, and brook trout *Salvelinus fontinalis* are the most common introduced fish species in high mountain lakes in the Clearwater Region. Although many lakes within the study area have a stocking history that may include Yellowstone cutthroat *O. bouvieri*, California golden trout *O. mykiss* subspecies (last stocked in 1990 in the Clearwater Region – Steep Lakes), and arctic grayling *Thymallus arcticus* (last stocked in 1982 in the Clearwater Region – Bald Mountain Lake), and various forms of trout hybrids. The term introduced western trout may be more appropriate for trout species in these lakes where natural reproduction is occurring, as the degree of hybridization is unknown in lakes where multiple species have been stocked (Behnke 1992). Currently, stocking efforts continue on a three-year rotation by fixed wing aircraft stocking mostly westslope cutthroat.

Brook trout tend to impact Columbia spotted frog and especially long-toed salamander occurrence and breeding to a greater extent than the presence of either *Oncorhynchus* species due to differences in fish spawning times/behavior and variations in amphibian habitat usage following spring ice off in high mountain lakes (Murphy 2002). Spring/summer spawning of westslope cutthroat and rainbow trout often coincides with amphibian breeding. As a result westslope cutthroat and rainbow trout are typically preoccupied with spawning in inlets or outlets while amphibians are typically breed within the lake itself. The difference is habitat use spawning allows amphibians to breed with fewer disturbances by westslope cutthroat and rainbow trout (Murphy 2002). Whereas, brook trout (char) being fall spawners are actively moving and foraging throughout the lake and more likely to prey upon any amphibian life-stage and/or harass breeding adults (Murphy 2002). Furthermore, brook trout tend to be more benthic oriented (where salamanders usually occur), utilize larger prey items, and attain higher densities within mountain lakes than *Oncorhynchus* species (Griffith 1974). Columbia spotted frogs do not tend to be impacted by brook trout presence to the same magnitude (as long-toed salamanders) because of their different habitat associations and shorter length of larval stages.

Long-toed salamanders occupy a wide range over the western United States and Canada. The majority of long-toed salamanders in Idaho sub-alpine lakes have a two year larval stage, creating a longer temporal susceptibility to fish predation than the Columbia Spotted Frog (Murphy 2002). No research has provided conclusive evidence that long-toed salamanders populations are declining within their respective ranges or that ranges are contracting (Graham and Powell 1999). For this reason a long-term monitoring project (20 years) was initiated in the Clearwater Region to provide knowledge of the amphibian population dynamics within the north central mountains of Idaho. Long-term monitoring of mountain lakes will identify long-term trends in amphibian populations providing more latitude in the conservation and preservation efforts of amphibian habitat selection and sustainability.

The year 2009 was the fourth year of a 20-year monitoring effort of mountain lakes within the IDFG Clearwater Region. This collaborative mountain lakes monitoring program examines amphibian populations, fish populations, and habitat parameters at a watershed (HUC 5) landscape scale.

OBJECTIVES

1. Evaluate the long-term impacts of fish on amphibian populations within the high mountain lake ecosystems in the IDFG Clearwater Region.

2. Assess whether current fish management in high mountain lakes of North Central Idaho is sufficient to provide long-term persistence of amphibian populations.

STUDY SITES

The Bitterroot National Forest, Clearwater National Forest, and Nez Perce National Forest are located in North Central Idaho (Figure 1). Within the Bitterroot, Clearwater, and Nez Perce National Forests are eight, fourth field hydrologic unit code (HUC 4) sub-basin drainages, containing 105, fifth field hydrologic unit code (HUC 5) mountain lake management areas. The HUC 4 sub-basin drainages include: the North Fork of the Clearwater River, the South Fork of the Clearwater River, the Lochsa River, the Upper and Lower Selway River, the Middle Fork and Lower Salmon rivers, and the Hells Canyon reach of the Snake River. The 105 HUC 5 watersheds were assessed and assigned an amphibian risk class (none, low, moderate, and elevated) and two were randomly chosen to represent each risk class for long-term monitoring over the next 20 years (Figure 2).

In 2009, IDFG and USFS personnel surveyed lakes within five HUC 5 watersheds. These watersheds included Bargamin Creek, Running Creek, and the North Fork Moose Creek from the Nez Perce National Forest. Watersheds within the Clearwater National Forest included Storm Creek and Warm Springs Creek.

The Bargamin Creek watershed is located in the south central portion of the Nez Perce National Forest (Appendix A). The lower portion of the watershed lies within the Frank Church Wilderness, and six of nine lakes within the watershed are in the Wilderness area. The Bargamin Creek HUC 5 watershed has a drainage area of approximately 28,883 ha and is a tributary to the Middle Salmon River HUC 4 sub-basin (Figure 1). Bargamin Creek drains into the Middle Salmon River from the north and is approximately 38.3 km in length. The main tributaries to Bargamin Creek are Cache Creek and Porcupine Creek which are approximately 9.9 and 7.7 km long, respectively, and each facilitate 7% of the watershed drainage before joining Bargamin Creek. There are nine mountain lakes within this watershed which encompass approximately 19.52 ha (Appendix B). The lakes range in elevation from 2,093 to 2,329 m, range in size from 0.53 to 8.05 ha, and have maximum depths ranging from 3.1 to 14.8 m (Appendix B). Eight of nine lakes within the watershed had been previously surveyed in 1989 as inventories to collect baseline data, prior to the implementation of mountain lakes monitoring in the Clearwater Region (Appendix C). Based on previous lake surveys, fish presence was documented in 77% of the lakes (7 of 9) which represented 92% of the available lake surface area (17.9 of the total 19.52 ha) (Table 1; Appendix A). At least one amphibian species was observed in eight of the nine lakes surveyed previously (1989 and 1995) (Appendix C). Of those lakes surveyed (8 of a total 9), Columbia spotted frogs were previously observed in 87% of lakes (7 of 8) and 95% of surveyed lake surface area (17.6 of 18.53 ha) (Appendix C). Long-toed salamanders were previously observed in 50% of lakes surveyed (4 of 8) and in 23% of surveyed surface area (4.25 of 18.53 ha) (Appendix C). Three Prong Lake had never been surveyed by the IDFG and the amphibian status within that lake was unknown but was suspected to contain both Columbia spotted frogs and long-toed salamanders (based on predictions from the Clearwater Region mountain lakes management plan) (Schriever 2006). Three Prong Lake was suspected to not contain a fish population (based on predictions from the Clearwater Region mountain lakes management plan) (Schriever 2006). In 2009, Three Prong Lake in the Bargamin Creek watershed was surveyed. The routes taken to access this lake, bathymetry/surrounding area map, and photos of the lake, can be viewed in Appendices D, E, and F.

The North Fork of Moose Creek HUC 5 watershed is located northeast portion of the Nez Perce National Forest and is directly south of the Warm Springs Creek watershed in the Clearwater National Forest and the entire watershed lies within the Selway Bitteroot Wilderness (Appendix A). The North Fork Moose Creek watershed has a drainage area of approximately 26,251 ha and is a major tributary to Moose Creek which drains into the Lower Selway River HUC 4 Subbasin (Figure 1). North Fork Moose Creek drains into Moose Creek from the northwest and is approximately 33.3 km in length. The main tributary to the North Fork of Moose Creek is West Moose Creek which is approximately 14.1 km long, and facilitates 31% of the watershed drainage before joining the North Fork of Moose Creek. There are 14 mountain lakes within this watershed, which encompass approximately 11.48 ha (Appendix B). The lakes range in elevation from 1901 to 2173 m, in size from 0.04 to 5.42 ha, and maximum depth from less than 1.0 to 4.5 m (Appendix B). Four of 14 lakes within the watershed had been previously surveyed (in 1988 and 2001) prior to 2006 (Appendix C). Lakes that were not surveyed previously were not suspected to contain any fish populations (based on predictions from the Clearwater Region mountain lakes management plan) (Schriever 2006). One of 14 lakes (7%) within the watershed contained fish (Isaac Lake), which encompasses 47% of the combined lake surface area (5.43 of a total 11.48 ha) (Table 1; Appendix C). At least one amphibian species was observed in the four of 14 lakes surveyed in 1988 and 2001 but an additional nine lakes that were suspected to contain Columbia spotted frogs (Appendix C). An additional seven lakes were suspected to contain long-toed salamanders (based on predictions from the Clearwater Region mountain lakes management plan) (Schriever 2006) (Appendix C). Columbia spotted frogs were observed in 100% (4 of 4) of those lakes surveyed previously and 100% of lake surface area surveyed (12.3 of 12.3 ha) (Appendix B). Long-toed salamanders were previously observed in 75% (3 of 4) of lakes surveyed and 63% of surveyed lake surface area (Appendix B). All Lakes (with the exception of one lake) within the North Fork Moose Creek watershed were surveyed in 2006 as part of the monitoring effort. Section 28 Lake in a remote portion of watershed was surveyed in 2009. The route taken to access Section 28 Lake (surveyed in 2009), bathymetry/surrounding area map, and a photo of this lake can be viewed in Appendices D, E, and F.

The Running Creek HUC 5 watershed is located in the south central potions of the Nez Perce National Forest and is directly to the north of the of the Bargamin Creek watershed (Appendix A). The Running Creek watershed has a drainage area of approximately 23,617 ha and is tributary to the Upper Selway River HUC 4 Subbasin (Figure 1). Running Creek drains into the Upper Selway River from the southwest and is approximately 32.9 km in length. The main tributary to Running Creek is Eagle Creek which is approximately 20.8 km long, and facilitates 27% of the watershed drainage before joining Running Creek. There are four mountain lakes within this watershed, which encompass approximately 9.21 ha (Appendix B). The lakes range in elevation from 2008 to 2222 m, in size from 0.17 to 8.37 surface ha, and in maximum depth from 1.0 to 14.0 m (Appendix B). Only Running Lake has been previously surveyed by the IDFG prior to 2006 (Appendix C). Running Lake contains brook trout while the other three lakes were suspected to not contain any fish populations. Running Lake makes up 25% (1of 4) of the lakes within the watershed but 91% of the available lake surface area (8.37 of the total 9.21 ha) (Table 1; Appendix B). Previous surveys (2001) found that one amphibian species (Columbia spotted frog) was observed in Running Lake (Appendix C). In 2009, one lake (Three Prong Lake) was surveyed within Running Creek (Appendix B). The Running Creek watershed was randomly chosen for the monitoring project but Running Lake had also been previously chosen for the biological control of brook trout project to help address the removal of an exotic/invasive fish species that likely impact native fish assemblages. The route taken to access Eagle Creek lake, bathymetry/surrounding area map, and a photo of this lake can be viewed in Appendices D, E, and F.

The Storm Creek HUC 5 watershed is located in the eastern portion of the Clearwater National Forest and all lakes in the watershed lie within the Selway Bitteroot Wilderness (Appendix A). The Storm Creek watershed has a drainage area of approximately 12,705 ha and is a tributary to the Lochsa River HUC 4 Subbasin (Figure 1). Storm Creek drains into Colt Killed Creek (formally White Sands Creek) from the northeast which drains directly into the Lochsa River. Storm Creek is approximately 22.95 km in length, the only major tributary in the watershed, facilitating 100% of the drainage. There are 14 mountain lakes in the in this watershed, which encompass approximately 33.37 surface ha (Appendix B). Lakes in the watershed range in elevation from 1963 to 2227 m, in size from 0.20 to 9.32 surface ha, in maximum depth from 0.6 to 21.9 m (Appendix B). All 14 lakes within the Storm Creek watershed have been previously surveyed by the IDFG in 1991, 1996, or 1997 (Appendix C). Based on previous surveys, fish presence was documented in 36% of lakes (5 of 14) and 44% of available lake surface area (14.81 of a total 33.37 ha) (Table 1; Appendix C). At least one amphibian was observed in all 14 lakes within the watershed surveyed previously (1991, 1996, and 1997) (Appendix C). Columbia spotted frogs were previously observed in 100% (14 of 14) of lakes within the watershed and 100% of surface area within the watershed (33.37 of 33.37 ha) (Appendix C). Long-toed salamanders were previously observed in 57% of lakes (8 of 14 lakes) and 54% of lake surface area (17.93 of 33.37 ha) (Appendix C). In 2009, five lakes were surveyed and included Dan, Middle Storm, North Section 25, North Storm, and South Section 25 (Appendix B). Routes taken to access these lakes, bathymetry/surrounding area maps, and photos of each lake can be viewed in Appendices D, E, and F.

The Warm Springs Creek HUC 5 watershed is located in the central eastern portion of the Clearwater National Forest (Appendix A). The upper portion of the watershed lies within the Selway Bitterroot Wilderness and all lakes are within the wilderness area. The Warm Springs watershed has drainage area of approximately 18,421 ha and is a tributary to the Lochsa River HUC 4 Subbasin (Figure 1). Warm Springs Creek drains into the Lochsa from the south and is approximately 23.8 km in length. The main tributary to Warm Springs Creek is Wind Lakes Creek which is approximately 12.2 km long, and facilitates 28% of the watershed drainage before joining Warm Springs Creek. There are ten mountain lakes within this watershed, which encompass approximately 28.6 surface ha (Appendix B). The lakes range in elevation from 1882 to 2263 m, in size from 0.22 to 9.85 surface ha, and in maximum depth from 1.0 to 12.2 m (Appendix B). All lakes within the Warm Springs Creek watershed have been previously surveyed by the IDFG in 1991, 1995, or 1996 (Appendix C). Based on previous lake surveys, fish presence was documented in 40% of the lakes (4 of 10) which represented 88% of the available lake surface area (17.9 of the total 25.2 ha) (Table 1; Appendix C). At least one amphibian species was observed in all ten lakes surveyed previously (1991, 1995 and 1996) (Appendix C). Columbia spotted frogs were previously observed in 90% of lakes (9 of 10) and 98 % of surface area (28.04 of a total 28.63 ha) (Appendix C). Long-toed salamanders were previously observed in 80% of lakes (8 of 10) and 38% of surface area (10.92 of a total 28.63) (Appendix C). In 2009, two lakes within the Warm Springs Creek watershed were surveyed and included Northwest Wind and Dodge (Middle Wind and West Wind Lakes fish surveys were also completed in 2009). Routes taken to access these lakes, bathymetry/surrounding area maps, and photos of each lake can be viewed in Appendices D, E, and F.

METHODS

Sampling protocol can be separated into three separate sections including examining indicators of amphibian populations, fish stock, and lake habitat characteristics (Appendix G). Amphibians were surveyed by using a modified Visual Encounter Survey (VES) (Crump and Scott 1994). All amphibians encountered were counted and identified to species and life stage. Amphibian larvae (especially Columbia spotted frogs) were encountered in large groups and were denoted in data sheets a Too Many To Count (TMTC). Amphibian surveys were performed from shore or by wading through the littoral zone when the stability of the lake substrate permitted.

A single overnight gill net set (~12 hrs. with one net) was placed in each lake to assess the fishery. Gill nets were set and retrieved by the use of a float tube. Gill nets used were packable Swedish multi-meshed nets that were 40 m in length and contained three panel sizes ranging from 10-38 mm. The nets were set perpendicular to the shore with the smallest panel size set nearest to the shore. Captured fish were weighed and measured for total length. Stomach samples and scales were collected from all fish mortalities which was usually high among trout. Stomach samples analyses will be used to determine if trout captured in the gill net were preying upon amphibians. Scale samples collected will be used to determine fish age and will be compared to stocking records to determine if natural recruitment is occurring. Fish data will be analyzed by examining length frequency indices and catch-per-unit-effort (CPUE) for each gill net set. Length and weight relationships were analyzed by a length weight linear regression which is described by (Log_{10} of weight) = Y intercept + slope (Log_{10} of total length). Relative weights were also determined using index developed by Wege and Anderson (1978), calculated by $W_r=W/W_s$, where W_r is the relative weight, W is the actual weight (g), and W_s is the 75^{th} percentile length specific-standard weight. The standard weight used in the equation was proposed for rainbow trout populations by Anderson (1980) and for interior lentic cutthroat populations by Kruse and Hubert (1997).

Zooplankton samples were collected from a series of horizontal shallow tows (at 5 m in length from shoreline and just below lake surface) and vertical deep tows (at the maximum depth in the lake) using a 254 mm (ten inch) diameter circular net. Aquatic invertebrate families present at each lake were recorded when VES was performed. Water chemistry measurements were also collected and included: water surface temperature, pH, and conductivity. A site map of each lake surveyed was developed including lake depth (bathymetry) determined by making multiple traversing passes across each lake with a portable depth sounder (Appendix E). Each lake was given a brief description including: location of surrounding forest, talus slopes, head walls, inlets, outlets, associated wetlands, large rocks, woody debris, and descriptions of access to the lake. Substrate composition was visually estimated for the lake littoral zone and deeper visible areas. Species of trees and their relative composition was recorded for the surrounding forested areas adjacent to the lakes. Metadata for each lake included: name, survey date, time, weather, slope, aspect, national forest, ranger district, campsite inventories, and directions/distance from trailheads. Zooplankton samples were stored in the IDFG Clearwater Region laboratory and will be analyzed by keying sample specimens to order, determining a density of each order for the volume of water from each tow, and determining lengths of adults from each order. Other physical lake parameters will be analyzed on a four year basis when comparisons are made across amphibian risk categories and within watersheds (trend monitoring). A spreadsheet was developed that contains all survey data collected during mountain lakes monitoring (2006 - 2009) (S:\Fishery\MTN Lakes\Mtn. Lakes monitoring and biological control\State Lakes Database, Monitoring Spreadsheets, and Revised Data sheet). This data set will be used to evaluate long term trends of fish presence, amphibian presence, and factors that may be influencing any fish or amphibian population trends.

Study Design and Protocol Development

Prior to the 2006 high mountain lakes field season, a mountain lakes, long-term monitoring study design and protocol was developed. The study design and protocol addressed the amphibian risk assessment that has been developed through previous studies and inventories of high mountain lakes within North Central Idaho conducted by Bahls, Brimmer, and Murphy (Schriever 2006). The amphibian risk assessment is based on the amount of fishless habitat that exists within a watershed at the HUC 5 level. At the individual HUC5 watershed level it is assumed monitoring will be able to examine conditions that may dictate local response in the interactions of stocked fish and native amphibian populations to provide a more defined opportunity for prioritized management action (Murphy 2002). While there are many risk factors associated with amphibian declines, our assessment focused on considering impacts that may be associated with native and stocked fish in lakes on a HUC 5 watershed basis. The amphibian risk assessment for these high mountain lake ecosystems has four categories: control or no risk, low, moderate, and elevated (Figure 2; Table 1).

- *Control or no risk* – watershed has never experienced fish introductions through stocking activities.
- *Low* – At least 50% of the lakes within a watershed are fishless <u>AND</u> a minimum 20% of the lake surface area within the watershed is fishless.
- *Moderate* – 50% of lakes within a watershed are fishless <u>OR</u> 20% of surface area is fishless.
- *Elevated* – Meets neither requirement, less than 50% of the lakes within a watershed are fishless <u>AND</u> less than 20% of the surface area within the watershed is considered fishless.

Two watersheds (HUC 5) were selected randomly from each of the amphibian risk categories (Region wide from all HUC 5 watersheds that contained lakes) for sampling. This resulted in five HUC 5 watersheds containing 33 lakes within the Nez Perce N.F. and three HUC

5 watersheds containing 40 lakes within the Clearwater N.F. Attempts will be made to sample all lakes within a selected watershed within the same field season. The 20 year period for the high mountain lakes long-term monitoring project will allow for the lakes in two randomly selected HUC 5 watersheds to be sampled each field season. Each selected watershed will then be sampled in five efforts over 20 years. The repetition of sampling events will allow for comparisons to be made within (for trends) and between watersheds (for comparisons among amphibian risk classes). In addition, repetition of sampling events will address the normal patterns of recruitment fluctuations often common among amphibian populations. Lakes within Bargamin Creek, North Fork Moose Creek, Storm Creek, Running Creek, and Warm Springs Creek HUC 5 watersheds were selected for sampling in 2009 (Figure 2; Table 1). The following is a list of the HUC 5 watersheds that were randomly selected.

- Control (no risk category)
    - Goat Creek HUC 5 watershed from the Upper Selway River
    - Upper Meadow Creek HUC 5 watershed from Lower Selway River
- Low risk category
    - N.F. Moose Creek HUC 5 watershed from Lower Selway River
    - Storm Creek HUC5 watershed from Lochsa River
- Moderate risk category
    - Running Creek HUC 5 watershed from Upper Selway River
    - Warm Springs Creek HUC 5 watershed from Lochsa River
- Elevated risk category
    - Bargamin Creek HUC 5 watershed from Middle Salmon River
    - Old Man Creek HUC 5 watershed from Lochsa River

<u>Statistical Analysis</u>

Evaluation of the long-term impacts of fish on amphibian populations within the high mountain lake ecosystems in the IDFG Clearwater Region will be assessed as multiple sampling rotations have been completed. The statistical methodology described below explains how we will evaluate the long-term impacts of fish on amphibian populations.

Incorporating detection probabilities in estimates of proportion of area (POA) occupied by an amphibian species can provide estimates of occupancy that are relatively unbiased in comparison to naive estimates of occupancy which tend to underestimate true POA (detection by total number of lakes or surface area within a watershed) (MacKenzie et al. 2002; Muths et al. 2005). Incorporating detection probabilities from multiple detection/nondetection surveys in POA estimates may be especially important for long-toed salamander larvae in mountains lakes that are often cryptic in both coloration and behavior often resulting in a false nondetection. The spreadsheet based program PRESENCE allows for the incorporation of sampling and site-specific covariates that tend to impact the probabilities of detection and occupancy for a given amphibian or reptile species. Sampling covariates are parameters that may vary with each survey such as; weather conditions, time of day, or observer, whereas site specific covariates vary by site (but are constant for that site throughout the year), such as; littoral zone composition, lake size, fish presence/density, and hydroperiod (MacKenzie 2002). Sampling covariates influence detection probabilities, whereas site specific covariates influence detection and/or occupancy probabilities. Probability of detection (p) references that a given species is detected at a site that is truly occupied and probability of occupancy (ψ) refers to a species present at a given site (Muths et al. 2005).

The program PRESENCE uses the Akaike Information Criteria (AIC) to examine models based on detection/nondetction data, sampling covariates, and site specific covariates to select the most parsimonious model (Akaike 1973; Burnham and Anderson 2002; Muths et al. 2005). The PRESENCE program also uses a goodness of fit test to evaluate the global or most parameterized model, over-dispersion, and variance (and variance inflation factors if necessary) (Burnham and Anderson 2002; Mackenzie and Bailey 2004; Muths et al. 2005). Analysis of the detection/nondetection data collected by the IDFG in North Central Idaho would likely need to be analyzed a multiple season model (after completion of second sampling rotation and for every round of sampling, thereafter). Analysis of amphibian POA data with PRESENCE would allow for analysis for the regional concerns but may also ease transition of data into a larger national amphibian database maintained by the Amphibian Research and Monitoring Initiative (ARMI) at a later date.

RESULTS

Mountain lakes field personnel surveyed twelve lakes in 2009 (one lake from Bargamin Creek, one lake from North Fork Moose Creek, one lake from Running Creek, five lakes from Storm Creek, and four lakes from Warm Springs Creek) (Appendix B). Fish surveys from two lakes in Warm Springs Creek (surveyed in 2008) were completed in 2009, while two other fishless lakes in the watershed were sampled in their entirety in 2009.

Bargamin Creek HUC 5 Watershed

The one Bargamin Creek watershed lake surveyed in 2009 was Three Prong Lake. Three Prong Lake had a surface area of 0.99 ha, maximum depth of 2.7 m, and an elevation of 2,192 m (Appendix B). Three Prong Lake has never been surveyed by the IDFG before 2009; all other lakes within the Bargamin Creek watershed were previously sampled throughout 1989 and 1995 (Appendix C). In 2008, MacArthur Lake and Stillman lakes were sampled in the monitoring effort, while six other lakes (Bleak Creek, Boston Mountain, Goat, and Lake Creek lakes East, South, and West) in the watershed, remain to be sampled under the monitoring effort (Appendix B). In 2009, no fish were observed in the lake sampled (Three Prong) while; two amphibian species (Columbia spotted frogs and Idaho giant salamanders) were observed (Appendix B).

No fish were observed in Three Prong Lake and this lake was never suspected to have supported a fish population based on predictions made in the Clearwater Region mountain lake management plan and final report (Schriever 2006). Furthermore, there is no record of a stocking history for Three Prong Lake, as this particular lake was classified as a management classification of I.B. (a fishless lake with no stocking record) (Appendix F). Three Prong Lake was likely never stocked by the IDFG due to the moderately small size (0.99 ha) and the relatively shallow maximum depth of the lake (2.7 m).

Three Prong Lake had never been surveyed prior to 2006 and the observations of amphibians during the 2009 survey will act as baseline information from which comparisons to future surveys can be made. Columbia spotted frogs (adults, sub-adults, and larvae) and Idaho giant salamanders (adults) were observed during the VES of Three Prong Lake in 2009 (Table 4; Appendix B). Long-toed salamanders were not observed in the 2009 survey of Three Prong Lake. Columbia spotted frog larvae were observed in Three Prong Lake, thus this lake likely serves as a breeding area for Columbia spotted frogs (Table 4). No, Columbia spotted frog egg masses or breeding activities were observed in Three Prong Lake, likely due to the timing of the survey (September). Paedomorphic (adults that retain juvenile and aquatic characteristics) Idaho giant salamanders were observed in Three Prong Lake (adult terrestrial form of Idaho giant salamander is uncommon) (Table 4). No Idaho giant salamander breeding activity or egg masses were observed in the 2009 survey of Three Prong Lake.

North Fork Moose Creek HUC 5 Watershed

The one lake surveyed in the North Fork Moose Creek watershed during 2009 was Section 28 Lake. Section 28 Lake has a surface area of 0.50 ha, a maximum depth of 1.6 m, and an elevation of 2,074 m (Appendix B). All other lakes (13 of 14) in the watershed were surveyed in 2006 (Appendices B). In 2009 no fish were observed in Section 28 Lake while, both Columbia spotted frogs and long-toed salamanders were observed (Table 4; Appendix B).

There are no indications that Section 28 Lake has ever supported fish based on predictions made in the Clearwater Region mountain lake management plan (Schriever, 2006) and because there is no record of a stocking history. As a result Section 28 Lake, was classified as a management classification of I.B. (a fishless lake with no stocking record) (Appendix H). Section 28 Lake was likely never stocked by the IDFG due to the relatively small size (0.50 ha) and the relatively shallow maximum depth of the lake (1.6 m).

Historical VES inventory information (2001) confirms that both Columbia spotted frogs and long-toed salamanders were observed during the last survey of Section 28 Lake (Appendix C). In a 2009 monitoring survey of Section 28 Lake, both Columbia spotted frogs and long-toed salamanders were observed (Table 4; Appendix B). Columbia spotted frog adults, sub-adults, and larva were observed during this survey (Table 4). The observations of Columbia spotted frog larva represents that breeding is occurring within this lake. The presence of long-toed salamander larva (no adults observed) indicates that this species is also breeding in this lake (Table 4). Observations of both Columbia spotted frogs and long-toed salamanders in Section 28 Lake represents no change from occupancy determined from surveys before monitoring was implemented (2001) (Appendices B and C). Based on inventory (1988 and 2001) and monitoring (2006 and 2009) information, Columbia spotted were observed in 100% of the lakes (14 of 14) and 100% (11.48 of 11.48 ha) of surface area within the watershed, while long-toed salamanders were observed in 50% of lakes (7 of 14) and 35% of available lake surface area (4.05 of 11.48 ha) (Appendices B and C). When the observational information from 1998 and 2001 (four lakes surveyed) is compared to that of 2006 and 2008, Columbia spotted frog occupancy by lake number and surface area remains the same, however long-toed salamander occupancy decreased from 75% of lakes surveyed (3 of 4 lakes) and 21% of lake surface area (1.48 of 6.91 ha) to 25% of lakes surveyed (1of 4 lakes) and 7% of lake surface area (0.50 of 6.91 ha) (Appendix B). Thus, Columbia occupancy remains the same across those four lakes but long-toed salamander occupancy has decreased by 50% in lake number and by 14% of lake surface area, based on the four lakes surveyed for both inventories and monitoring.

Running Creek HUC 5 Watershed

The one lake surveyed in the Running Creek watershed during 2009 was Eagle Creek Lake. Historically Eagle Creek Lake had a surface area of 0.27 ha, an undetermined maximum depth, and an elevation of 2,222 m (Appendix B). A maximum depth was undetermined because Eagle Creek Lake had never been surveyed by the IDFG prior to 2009 survey. Eagle Creek Lake was no longer a standing body of water in 2009 as sediment deposition, excessive plant growth, and reduced inflow, and/or inlet diversion have contributed to this lake becoming a dry meadow (Appendix F). No fish or amphibian species were observed in (the dry) Eagle Creek Lake (Table 4; Appendix B). Columbia spotted frogs but not long-toed salamanders were predicted (by the management plan) to occupy Eagle Creek Lake.

All other lakes (Running, Section 26 upper and lower) in the watershed were surveyed in 2008 (Appendix B). Running Lake was the only lake within the watershed that was surveyed prior to 2006 (surveyed in 2001). Three of four lakes (Section 26 lakes and Eagle Creek Lake) had never been surveyed prior to 2006, thus the first year of monitoring will act as baseline information for these lakes. Columbia spotted frogs were observed in the one lake (Running Lake) surveyed prior to 2006 and were not observed in any lakes surveyed in 2008 or 2009 (Appendix B). Long-toed salamanders were observed in one lake (Section 26 Lake upper) in 2008.

The change of Eagle Creek Lake to a dry meadow reduced the number lakes in the watershed by 25% (from four to three), and overall lake surface area by 3% (from 9.21 to 8.94 ha). Eagle Creek Lake was designated as an I.B. management classification (fishless lake with no stocking record) (Appendix H). Eagle Creek was likely never historically stocked by the IDFG because of the relatively small size of the lake.

Storm Creek HUC 5 Watershed

The five lakes surveyed in the Storm Creek watershed during 2009 were Dan Lake, Middle Storm Lake, North Storm Lake, North Section 25 Lake, and South Section 25 Lake. Surface areas of these lakes ranged in size from 2.16 to 0.20 ha, in maximum depths from 3.3 to 1.0 m, and in elevation from 2,227 to 2,019 m (Appendix B). Other lakes (5 of 14) in the watershed were surveyed in 2007, leaving four other lakes to be surveyed (Appendix B). All lakes within the watershed were previously sampled for inventory purposes during 1991, 1996, and 1997 (Appendix C). In 2009, fish (rainbow trout) were observed in one of five lakes (Dan Lake) surveyed in the Storm Creek watershed and at least one amphibian species was present in each of the five lakes surveyed (Table 4; Appendix B).

The presence of rainbow trout in Dan Lake represents no change from information collected prior to 2006 (Appendix B). Stocking records indicate that Dan Lake was last stocked with 600 rainbow trout fry and with 784 cutthroat trout fry in 1974. Dan Lake is considered a II.B. management classification type (fish present with a high level of natural reproduction) (Appendix H). An overnight gill net set (12.00 hrs) on Dan Lake captured 26 rainbow trout with a CPUE of 2.17 fish per hour (Table 2). Rainbow trout captured in Dan Lake ranged in total length from 95 to 368 mm with a mean of 226 mm and ranged in weight from 10 to 270 g with a mean of 100 g (Figures 3 and 4; Table 3). The mean W_r was 76 (Figure 5; Table 3). The length weight relationship for rainbow trout captured in Dan Lake can be described by the equation $y = -3.7265 + 2.4161x$, rate of change was 2.4, and R^2 value was 0.96 (Figure 6). Natural reproduction of introduced rainbow trout is most likely occurring as evidenced by the presence of fish 95 mm in length and the last stocking date of any fish species in 1974.

Historically, Columbia spotted frogs and long-toed salamanders were observed in certain mountain lakes within the Storm Creek HUC 5 watershed (Appendix C). Prior to 2006 Columbia spotted frogs were observed in all five lakes surveyed in 2009 from the Storm Creek watershed (Appendix C). In 2009, Columbia spotted frogs were also observed in all five lakes (4.31 total ha) (Tables 4; Appendix B). Columbia spotted frog breeding was observed to have occurred (observations of larvae) in all five lakes (Table 4). Based on historical information long-toed salamanders were observed in 60% of lakes (3 of 5) and 35% of available lake surface area (1.52 of 4.31 ha) (Appendix C). In 2009, long-toed salamanders were not observed in any of these lakes (Table 4; Appendix B). The decrease in long-toed salamander observations occurred in lakes that were fishless as the only lake (of five) surveyed in 2009 to contain fish (Dan Lake), in which long-toed salamanders were not observed prior to 2006.

Warm Springs Creek HUC 5 Watershed

The four lakes surveyed in the Warm Springs Creek watershed were; Dodge, Middle Wind, Northwest Wind, West Wind. Dodge and Northwest wind lakes were completely surveyed in 2009. Middle and West Wind lakes were surveyed for fish in 2009, completing those surveys initiated in 2008). Surface areas of these lakes ranged in size from 5.77 to 0.71 ha, in maximum depths from 7.0 to 1.0 m, and in elevation from 2,072 to 1,882 m (Appendix B). All ten lakes within the watershed were previously surveyed during 1991, 1995, or 1996. In 2009, fish (cutthroat trout) were present in 50% of lakes surveyed (2 of 4) and 82% of the lake surface area surveyed (7.76 of 9.36 ha) (Appendices B and C). At least one amphibian species was present in each of the four lakes surveyed in 2009.

Westslope cutthroat trout were the only fish species sampled in the two lakes containing fish, the same as was observed in historic surveys (Appendices B and C). Records indicate that westslope cutthroat were last stocked in the Wind Lakes Area in 1951 (Middle Wind Lake) and 1965 (West Wind Lake). These two lakes are considered a II.A. management classification type (fish present with low/moderate natural reproduction) (Appendix H).

An overnight gill net set (13.16 hrs) on Middle Wind Lake captured 52 westslope cutthroat trout with a CPUE of 3.95 fish per hour (Table 2). Westslope cutthroat trout captured in Middle Wind Lake ranged in total length from 110 to 287 mm with a mean of 206 mm (Figures 3 and 7; Table 2). Westslope cutthroat trout captured in Middle Wind Lake ranged in weight from 10 to 250 g with a mean weight of 115 g (Table 3). Mean W_r of westslope cutthroat trout captured from Middle Wind Lake was 100 in 2009 (Figure 5; Table 3). The length weight relationship for westslope cutthroat trout captured in Middle Wind Lake can be described by the equation $y = -5.0407 + 3.0233x$, rate of change was 3.0 and the R^2 value was 0.89 (Figure 6). Natural reproduction of introduced cutthroat within Middle Wind is likely as fish smaller than 150 mm were captured in gill netting efforts and the last recorded stocking event was 1951.

An overnight gill net set (14.25 hrs) on West Wind Lake captured seven westslope cutthroat trout with a CPUE of 0.49 fish per hour (Table 2.) Westslope cutthroat trout captured in West Wind Lake ranged in total length from 301 to 380 mm with a mean of 340 mm (Figure; Table 2). Westslope cutthroat trout captured in West Wind Lake ranged in weight from 320 to 485 g with a mean weight of 388 g (Table 3). Mean W_r of westslope cutthroat trout captured from West Wind Lake was 107 in 2009 (Figure 5; Table 3). The length-weight relationship for westslope cutthroat trout captured in West Wind Lake can be described by the equation y = -4.3014 + 2.7538x, rate of change was 2.8 and the R^2 value was 0.96 (Figure 6). Low natural reproduction of introduced cutthroat within West Wind Lake is likely occurring as no fish smaller than 301 mm were encountered in gill netting efforts but the last recorded stocking event was in 1965. West Wind Lake was determined in 1995 to have limited spawning potential and low recruitment of introduced westslope cutthroat trout.

Prior to 2006, Columbia spotted frogs were observed in all four lakes (9.37 total ha) surveyed in 2008 (Middle and West Wind) and 2009 in the Warm Springs Creek watershed. Long-toed salamanders were historically observed in 50% of lakes (2 of 4) and 17% of surveyed lake surface area (1.61 of 9.37 ha) (Appendices B and C). In 2008 and 2009, Columbia spotted frogs were also observed in all four lakes surveyed (9.37 total ha) (Table 4; Appendix B), and long-toed salamanders were observed in 25% of lakes surveyed (1 of 4) and 8% of lake surface area surveyed (0.71 of 9.37 ha) (Table 4, Appendix B). Columbia spotted frog observations have not declined as compared to historical inventories, by lake number (4 of 4) or by surface area of those lakes surveyed (9.37 ha) (Appendices B and C). Columbia spotted frog breeding was observed to have occurred as larvae were detected in 25% of lakes (1 of 4) and 62% of lake surface area surveyed in 2008 and 2009 (Table 4; Appendix B). Long-toed salamander observations have decreased from 50% (2 of 4) of lakes historically to 25% (1 of 4) lakes in 2008 and 2009 and from 17% of surveyed lake surface area (1.61 of 9.37 ha) to 8% of lake surface area surveyed (0.71 of 9.37 ha) (Table 4; Appendix B). This represents a 25% decrease in observations in lake number and a 9% decrease in observations in lake area surveyed (Appendices B and C). This decline was observed only in lakes without fish. However of these four lakes, long-toed salamanders were never historically observed in those lakes with fish (Appendices B and C). Long-toed salamander breeding was observed to have occurred as larvae were detected in 25% of lakes (1 of 4) and 8% of lake surface area surveyed in 2008 (0.71 of 9.37 ha) (Table 4).

DISCUSSION

The year 2009 was the fourth year of the long-term monitoring project, thus temporal and spatial patterns in amphibian occurrences cannot yet be determined because multiple cycles of sampling are necessary. A long-term trend analysis of amphibian occurrence is needed to determine if fish presence and fishless habitat impact amphibians on a HUC 5 watershed basis.

The vast number of mountain lakes (~710) within the IDFG Clearwater Region has made it difficult to acquire historical data (inventory data) for every lake before beginning a monitoring program. Thus, the first year of monitoring for lakes with no historical inventory data will essentially act as historical data from which to make comparisons. Examples of such situations are Eagle Creek Lake and Section 26 lakes (upper and lower) from the Running Creek watershed surveyed in 2009 and 2008 respectively, Three Prong Lake from Bargamin Creek watershed surveyed in 2009, and to a larger extent the West Moose Creek Lakes (1-9) and Isaac Creek Lake from the North Fork Moose Creek watershed that were surveyed in 2006 (Appendices B and C).

For those lakes surveyed from 2006 to 2009, a general decline in amphibian presence was observed when compared to historic surveys. These declines were most prevalent for long-toed salamander. For those lakes with historical inventory information and that were surveyed as part of a monitoring effort from 2006 to 2009, Columbia spotted frogs observations decreased by approximately 14% in lakes (from 29 to 25 lakes), while long-toed salamander observations decreased by approximately 53% (from 19 to 9 lakes). A similar decline was evident, when observations by lake surface area was examined with Columbia spotted frog observation decreasing by 24% in lake surface area (from 67.73 to 51.57 ha) and long-toed salamander observation decreasing by 55% in lake surface area (from 33.84 to 15.34 ha). Columbia spotted frog observations decline was most prevalent in lakes with fish (four of five lakes contained fish) whereas long-toed salamander observations declines occurred in three of nine lakes that contained fish. Preliminary patterns such as this suggest that factors other than, or that compound the effects of fish presence are influencing the occurrence of amphibians in lakes, such as: fire activity, 10-15 year period of reduced snow pack and precipitation prior to 2006, changes in or variability in lake productivity, increases in UVA and UVB, water temperature or chemistry regime changes, changes in fish population structures, the high degree of variability in amphibian breeding, and/or amphibian infections or pathogens such as *Batrachochytrium dendrobatidis* (Bd Chytrid) the causative agent of chytridiomycosis (Blaustein et al. 1985; Carey 1993; Bradford et al. 1994; Gibbs 2000; Knapp et al. 2001, Daszak et el. 2003; Linder et al. 2003). In addition, multiple stressors may act to compound each other, influencing amphibian decline in many areas (Linder et al. 2003).

Overall and within watershed amphibian decline observed in 2006 - 2009 reflects only a portion of lakes and surface area, either because historical inventory information is lacking or not all of the lakes within the watershed have been sampled as part of the monitoring effort. After one full sampling rotation (2010 or 2011), comparisons will be made between watersheds (and amphibian risk assessments) and within watersheds (amphibian occupancy trends) where historical inventory information is complete. Thus, amphibian declines described here before one full sampling rotation must be viewed with caution.

Fire burned through sections of Bargamin Creek and Running Creek watersheds in 2003 and 2007. Fire effects were severe in some sections of Bargamin Creek where fire had burnt through riparian area of tributaries to Three Prong Lake. Furthermore, severe fires that destabilize slopes, increase sediment delivery, and fill and/or convert lakes to meadows or shallow wetlands. Fire effects may temporally disrupt breeding and amphibian movements which may change amphibian occupancy (based on rates of observations). However a study by Hossack and Corn (2007) has determined that fire may not negatively impact the distribution of long-toed salamanders or Columbia spotted frogs and that in recently burned wetlands both occupancy and colonization of each species actually increased for two to three years after the fire. Below average snow pack before 2006 (major form of precipitation in Northern Idaho), hot dry summers, accumulation of fuels, and exclusion of fire in some areas has possibly resulted in more severe fire effects in various areas. These drought like conditions also likely affected lake size, depth, and the number of lakes, all of which are predictors of salamander and frog occupancy (Owen 1989).

Eutrophication, infilling, and/or lower water levels within small lakes will impact the lake number and lake surface area within the watershed, which may have ramifications for mountain lake management, amphibian risk assessment classifications, and amphibian population dynamics. Furthermore, these small sized lakes (<0.5 ha) may be important breeding sites where fish are absent. Reduction of habitat connectivity likely affects dispersal and migration capabilities of wetland fauna impacted by the loss of these small wetlands assuming fauna like amphibians are strictly using wet migration corridors (Gibbs 2000). As eutrophication, infilling, and/or lower water levels of mountain lakes occurs, HUC 5 watershed amphibian risk amphibian categories are subject to change which may have an effect on the IDFG/USFS long-term mountain lakes monitoring effort (by changing the categories of watersheds already chosen by stratified random selection). The infilling of Eagle Creek Lake, North Wind Lake (lower), Bilk

Mountain Lake, and Section 27 Lake provide examples of change in total lake surface area and the amount of lakes in the Running Creek, Warm Springs Creek, Goat Creek, and Storm Creek watersheds respectively.

The reduction of overall lake number (2006 - 2009) within a HUC 5 watersheds typically occurred in what were historically recorded as small lakes (usually <0.50 ha) that are relatively shallow (usually <1.0 m deep). These small lakes typically were never stocked with fish, probably due to an overall shallow maximum depth. Mountain lakes that contain stocked fish populations are typically larger and deeper in order to provide over wintering areas for fish. These small lakes that likely never contained fish provide amphibian breeding and larval rearing areas that are important (possibly disproportionately so) in amphibian population dynamics within North Central Idaho. Yet these small lakes are most likely susceptible to drying up or infilling due to their comparatively small size. Furthermore, reduced water levels in all lakes throughout the study area may act to reduce overwintering areas for amphibians.

Despite that amphibian observations in high mountain lakes surveyed over the last four years have presented a declining trend, information collected from 2006-2009 represents only the beginning of a long-term trend monitoring program and analysis of comparisons within and between amphibian risk categories (watersheds) are yet to be determined. It is expected that amphibian observations will fluctuate over time depending on a host of factors including; weather patterns/disturbances, fluctuations in amphibian breeding, timing of surveys, and individual observer variability. Only after multiple sampling rotations through amphibian risk categories, can we determine with certainty the impact of high mountain lake stocking program on the long-term persistence of amphibian species. If long-term amphibian presence is determined to be put at risk by fish presence, then management can be modified to reduce this risk.

MANAGEMENT RECOMMENDATIONS

The continuation of monitoring of high mountain lakes within HUC 5 watersheds in the Clearwater Region is recommended as part of the long-term amphibian risk assessment. As part of the first sampling rotation, lakes remain to be sampled in Bargamin Creek (six lakes), Goat Creek (one lake), Old Man Creek (15 lakes), Storm Creek (four lakes), Upper Meadow Creek (three lakes), and Warm Springs Creek (one lake). As smaller lentic areas dry or infill, lake number and surface area reduction should be updated to determine if HUC 5 watersheds change in amphibian risk classification. Managers from the IDFG and USFS may want to consider a manner in which to classify fire effects documented in mountain lakes monitoring. Managers from the IDFG and USFS may also want to consider supplementary funding for additional field crews in the future to shorten the amount of time it takes to complete one full round of sampling.

ACKNOWLEDGEMENTS

Funding for 2009 high mountain lakes monitoring was a shared effort between the IDFG Clearwater Region and USFS Clearwater National Forest and Nez Perce National Forest. Personnel from IDFG and USFS cooperated on monitoring of lakes in the Clearwater National Forest, Nez Perce National Forest, and Selway-Bitterroot Wilderness. Field personnel that aided in 2009 mountain lakes monitoring include: Ed Kee from the USFS, Clearwater National Forest, Amadeus Guy from the USFS, Nez Perce National Forest, and Tim Kuzan from the IDFG, Clearwater Region.

Table 1. HUC 5 watersheds selected for mountain lakes monitoring project in consideration of an amphibian risk assessment. Table includes study HUC 5 watersheds, the National Forest in which each watershed is located, the accompanying amphibian risk assessment, and the amount of fishless lakes and lake surface area within each watershed.

HUC 5 Watershed	National Forest	Amphibian Risk Classification	% and # of Fishless Lakes	% and # of Fishless Surface Area
Goat Creek	Nez Perce	Control	100% (3 lakes)	100% (0.96 total ha)
Upper Meadow Creek	Nez Perce	Control	100% (3 lakes)	100% (1.64 total ha)
North Fork Moose Creek	Nez Perce	Low	93% (13 of 14 lakes)	53% (6.05 of 11.43 ha)
Storm Creek	Clearwater	Low	64% (9 of 14 lakes)	56% (18.56 of 33.37 ha)
Running Creek	Nez Perce	Moderate	75% (3 of 4 lakes)	9% (0.84 of 9.21 ha)
Warm Springs Creek	Clearwater	Moderate	60% (6 of 10 lakes)	12% (3.45 of 28.63)
Bargamin Creek	Nez Perce	Elevated	22% (2 of 9 lakes)	8% (1.52 of 19.52 ha)
Old Man Creek	Clearwater	Elevated	20% (3 of 15 lakes)	4% (3.14 of 75.76 ha)

Table 2. Summary of lengths of fish captured in (2009) overnight gill net sets in the Storm Creek and Warm Springs Creek HUC 5 watersheds in the Clearwater National Forest.

Lake name	CPUE (fish/hr)	Minimum length (mm)	Maximum length (mm)	Average length (mm)	Standard Deviation
Dan	2.17	95	368	225.73	51.88
Middle Wind	3.95	110	287	206.21	63.22
West Wind	0.49	301	380	339.57	29.58

Table 3. Summary of weights from fish captured in (2009) overnight gill net sets in the Storm Creek and Warm Springs Creek HUC 5 watersheds in the Clearwater National Forest.

Lake Name	Min. weight (g)	Max. weight (g)	Average weight (g)	Mean relative weight (W_r)	Standard deviation
Dan	10	270	100	75.90	50.37
Middle Wind	10	250	115.12	100.00	76.49
West Wind	320	485	388.33	107.79	86.07

Table 4. Summary of findings from visual encounter amphibian surveys in 2009 mountain lakes surveys from watersheds in Nez Perce and Clearwater National Forests.

Lake name	**Watershed**	**CSF adults**	**CSF subadults**	**CSF larva**	**CSF eggs**	**CSF total**	**LTS adults**	**LTS larva**	**LTS total**
Three Prong	Bargamin	4	21	TMTC/TMTC	0	25*	0	0	0
Section 28	NF Moose	22	76	TMTC	0	97*	0	31	31
Eagle Creek	Running	0	0	0	0	0	0	0	0
Dan	Storm	11	8	TMTC	0	19	0	0	0
Middle Storm	Storm	8	1	10	0	19	0	0	0
North Sec. 25	Storm	1	0	8	0	9	0	0	0
North Storm	Storm	1	2	TMTC	0	3	0	0	0
South Sec. 25	Storm	5	2	TMTC	0	7	0	0	0
Dodge	Warm Springs	36	32	10	0	78	0	0	0
NW Wind	Warm Springs	2	6	0	0	8	0	22	22

CSF=Columbia spotted frog, LTS=Long-toed salamander, TMTC=Too many to count,
*=TMTC designation disregarded for total count.

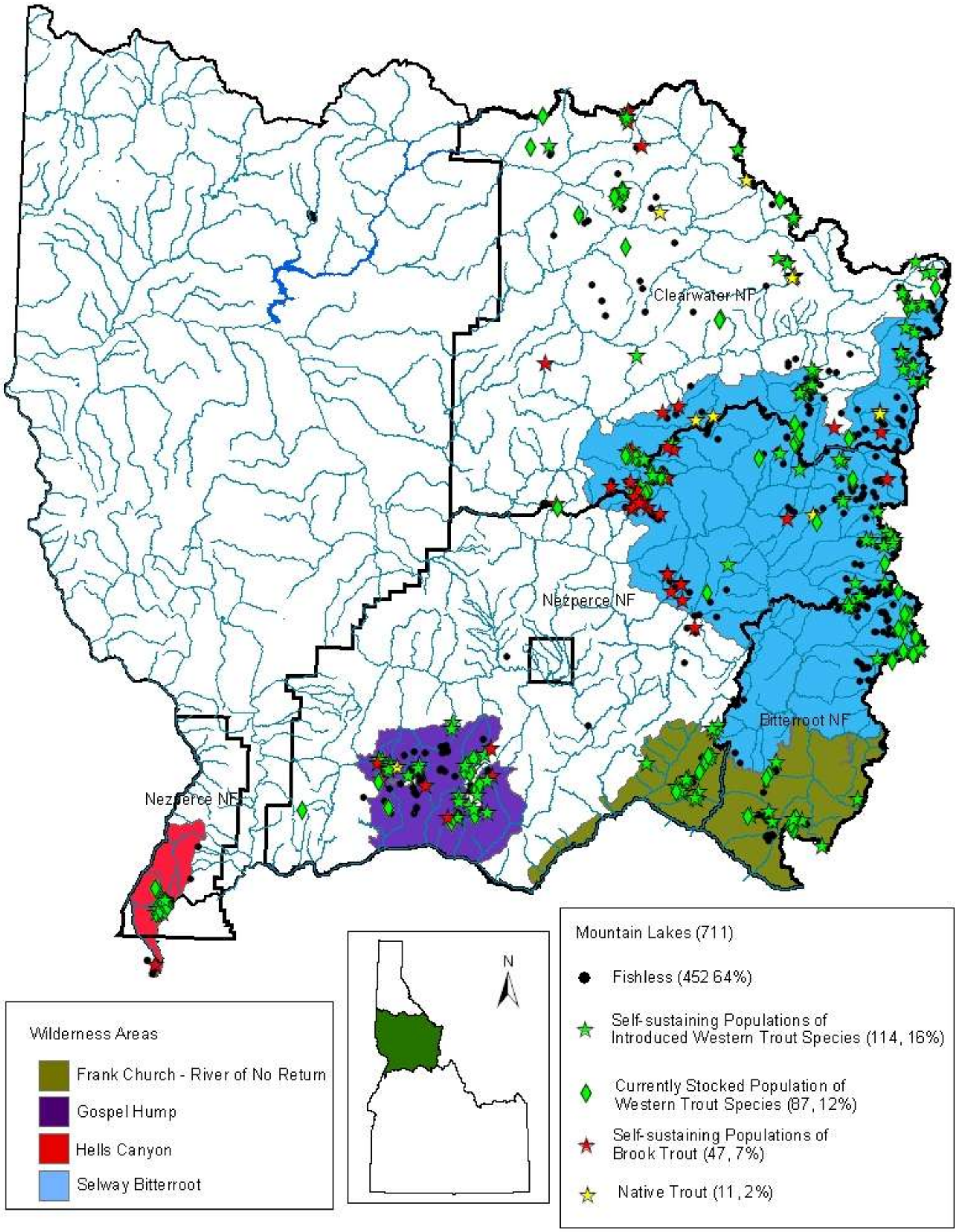

Figure 1. Distribution and fish related status of mountain lakes in the IDFG Clearwater Region indicating National Forest and Wilderness area boundaries.

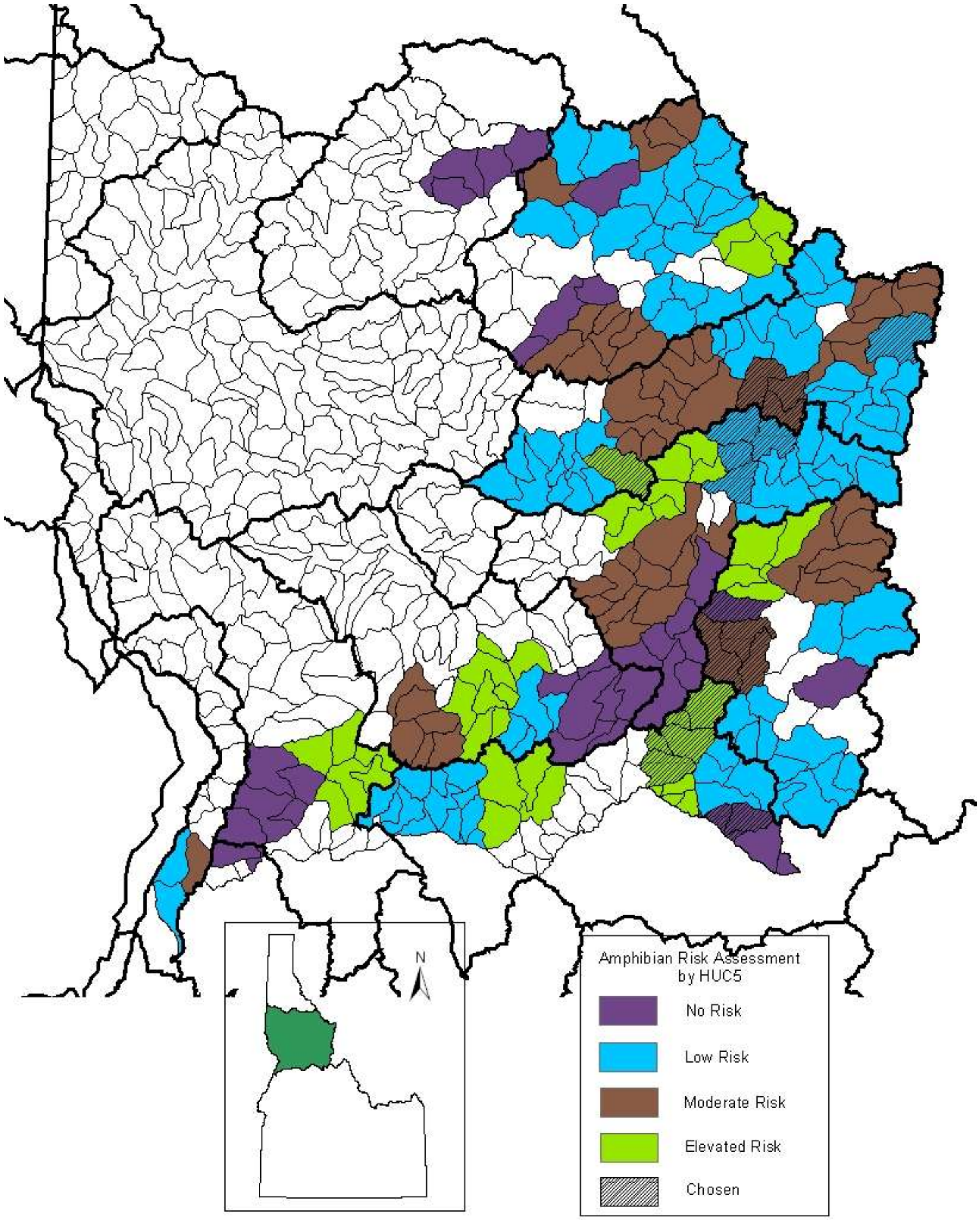

Figure 2. HUC 5 watersheds that contain mountain lakes classified by amphibian risk assessment with watersheds selected for monitoring in the Clearwater Region.

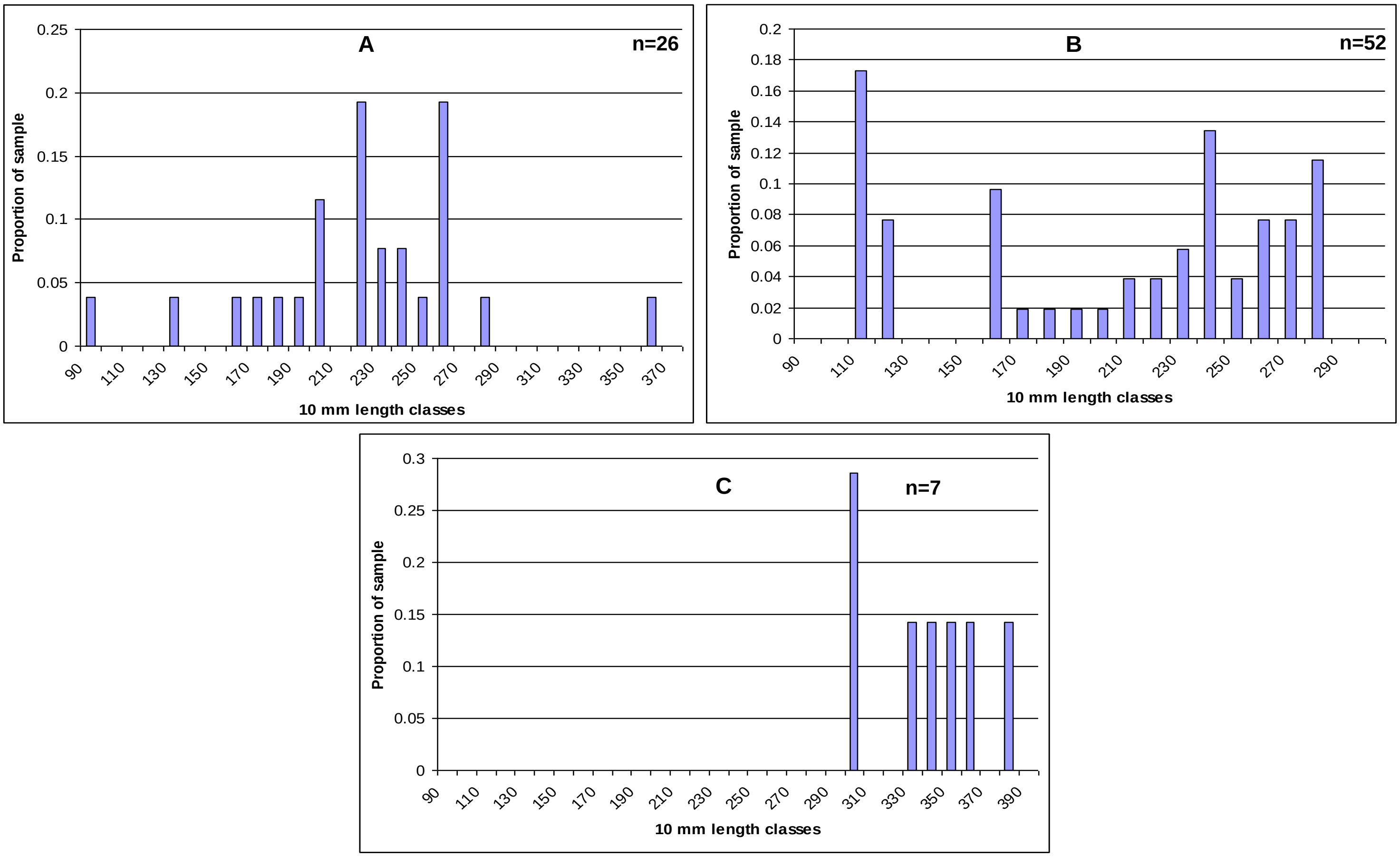

Figure 3. Length frequency histograms of trout captured in overnight gill net sets (2009). (A) Rainbow trout from Dan Lake (Storm Creek watershed), Clearwater National Forest. (B) Westslope cutthroat trout from Middle Wind Lake (Warm Springs Creek), Clearwater National Forest. (C) Westslope cutthroat trout from West Wind Lake (Warm Springs Creek), Clearwater National Forest.

Figure 4. Rainbow trout captured in overnight gill net set (2009) on Dan Lake (Storm Creek watershed), Clearwater National Forest.

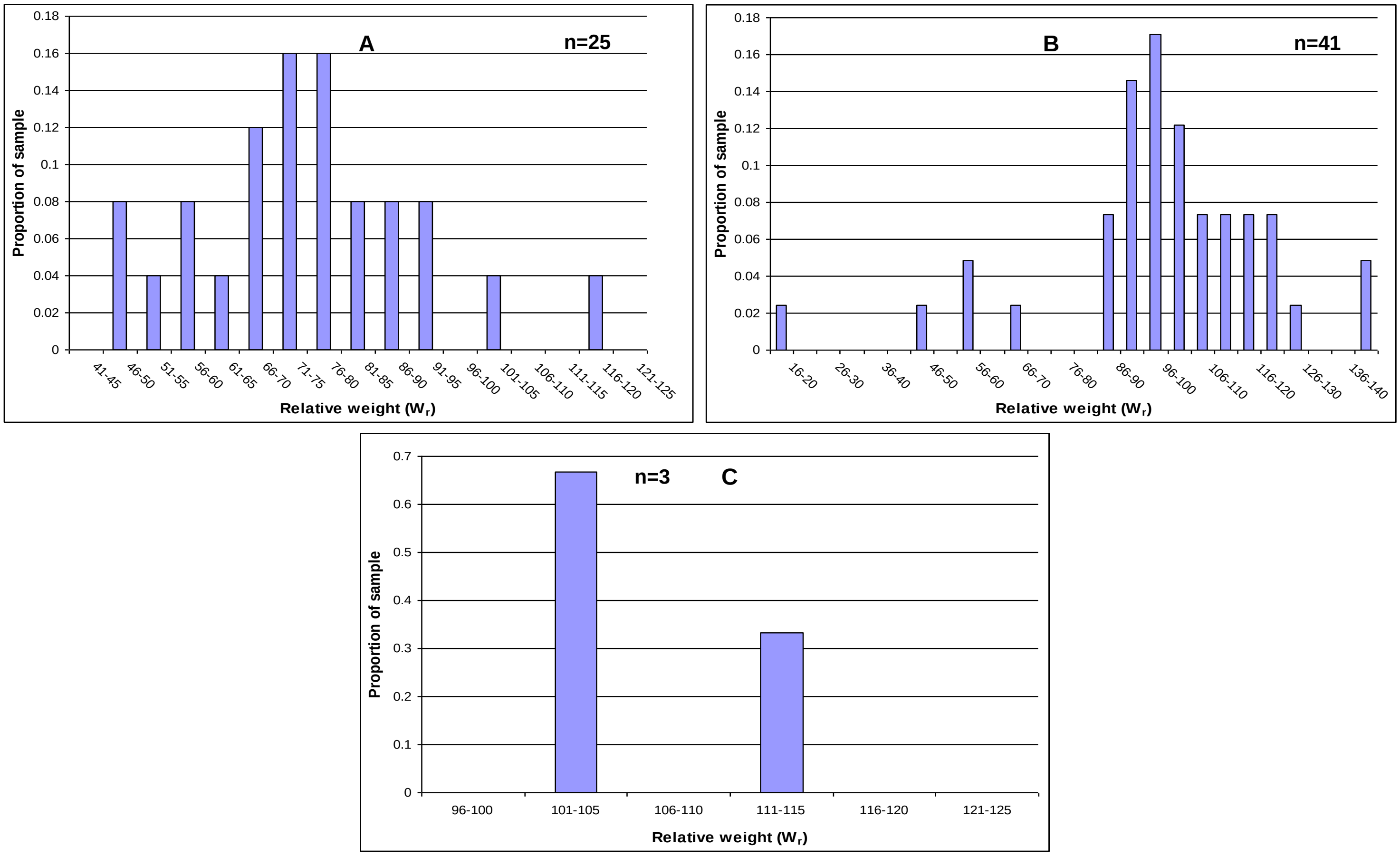

Figure 5. Relative weight (W_r) histograms of trout captured in overnight gill net sets (2009). (A) Rainbow Trout from Dan Lake (Storm Creek watershed), Clearwater National. (B) Westslope cutthroat trout from Middle Wind Lake (Warm Springs Creek), Clearwater National Forest. (C) West Wind Lake (Warm Springs Creek), Clearwater National Forest.

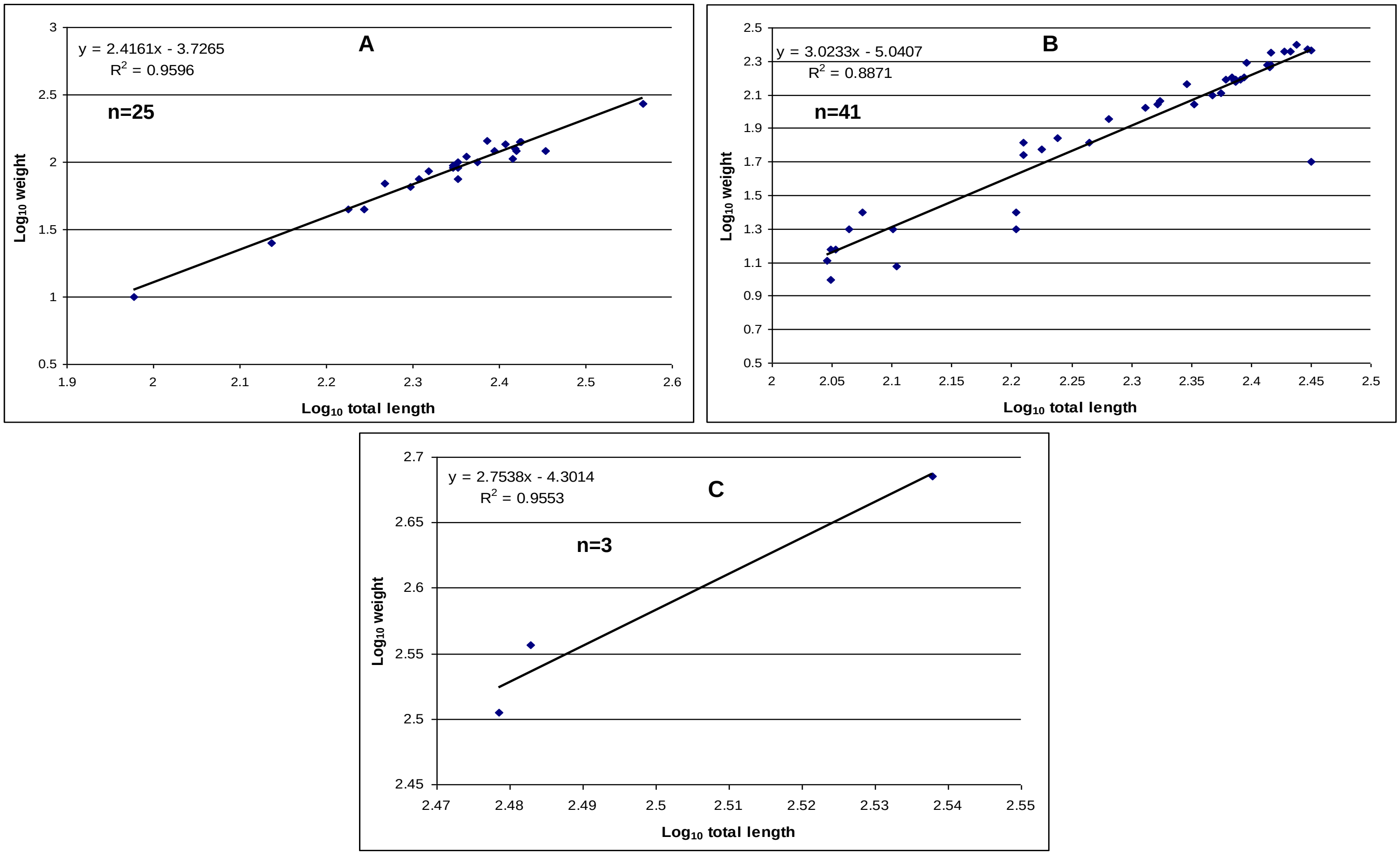

Figure 6. Length weight regression of trout captured in overnight gill net sets (2009). (A) Rainbow trout from Dan Lake (Storm Creek watershed), Clearwater National Forest. (B) Westslope cutthroat trout from Middle Wind Lake (Warm Springs Creek), Clearwater National Forest. (C) Westslope cutthroat trout from West Wind Lake (Warm Springs Creek), Clearwater National Forest.

Figure 7. Westslope cutthroat trout captured in overnight gill net set (2009) on Middle Wind Lake (Warm Springs Creek), Clearwater National Forest.

Tiger Muskellunge As A Biological Control Agent Of Brook Trout In North Central Idaho Mountain Lakes

ABSTRACT

In cooperative efforts between the Idaho Department of Fish and Game (IDFG) and the United States Forest Service (USFS), F_1 tiger muskellunge hybrids (male northern pike *Esox lucius* and a female muskellunge *E. masquinongy*) were stocked at high densities (40 fish/hectare of lake surface area) into four lakes containing brook trout populations on June 29, 2006. These lakes were Fly, Heather and Platinum lakes in the North Fork Clearwater River HUC 4 watershed and Running Lake in the Upper Selway River HUC 4 watershed. Petersen mark and recapture population estimates were conducted on these lakes using angling and gill netting to assess brook trout population abundance prior to the tiger muskellunge stocking on June 23-26, 2006 and October 30, 2004. All four lakes were resurveyed in 2007, 2008, and 2009 to assess changes in the brook trout abundance and size composition. Results from 2009 have showed that brook trout have been successfully removed from Fly Lake as no brook trout were captured in 2009 gill netting efforts and no brook trout were observed after visual searches of the lake. Brook trout CPUE levels generally decreased in three lakes (Fly, Heather, and Platinum) which are below CPUE levels observed pre tiger muskellunge introductions (2006). A general increase of brook trout CPUE was witnessed in Running Lake when compared to that of pre tiger muskellunge introductions in 2006 and post tiger muskellunge introductions in 2007 and 2008. A general shift toward increased lengths, weights, and conditions factors continued in Heather Lake with size classes smaller than 325 mm, no longer represented in the sample. Significant changes were found in mean ranked lengths of brook trout in Platinum and Running Lakes, but the trend of lengths, weights, and condition factors of in these lakes is not as definitive as in Fly or Heather lakes.

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INTRODUCTION

In the early to mid-20th century, brook trout were introduced into mountain lake ecosystems throughout Idaho. Brook trout were historically stocked into several lakes of the Five Lakes Butte area which drain into headwater streams of the North Fork of the Clearwater River (NFCR) forth field hydrologic unit code (HUC 4) drainage and some lakes within the Selway River HUC 4 drainage and in most instances continue to maintain self-sustaining populations (Figure 8). Some of these brook trout populations are subject to stunting due to high densities and relatively low productivity indicative of the mountain lakes in this area (Donald and Alger 1989; Hall 1991; Parker et al. 2001). Brook trout can often coexist with native fish species (Gunckel et al. 2002), although, brook trout have been found to impact bull trout *S. confluentus* populations through competitive interaction, predation, and hybridization (Scott and Crossman 1973; Cavnedar 1978; Leary et al.1983, 1993; Balon 1984; Markle 1992; Mullan at al. 1992; Rieman and McIntrye 1993). Bull trout populations within Idaho are currently listed as a threatened species under the Endangered Species Act (USFWS 1998). Brook trout have also been found to displace native westslope cutthroat through interspecific competition (Irving 1987; Griifith 1988; Dunham et al. 2000; Dunham et al. 2002). In addition to impacting native fishes, stunted brook trout populations may also discourage anglers from visiting such lakes (Rabe 1970; Donald et al. 1980; Donald and Alger 1989). The removal of brook trout should reduce the risks to native fish assemblages. However the removal of self-sustaining brook trout populations has proved difficult (Dunham et al. 2002).

One technique that has been attempted to eliminate and or control brook trout in mountain lakes is the introductions of tiger muskellunge (F_1 hybrid, a male northern pike *Esox lucius* and a female muskellunge *E. masquinongy*) (Curet et al. 2008; Kozfkay and Koenig 2006; Schriever and Murphy In Prep). Tiger Muskellunge males are functionally sterile and females have reduced reproductive capabilities. Consequently, there are very low risks of developing self-sustaining tiger muskellunge populations when stocked into water bodies. Tiger muskellunge have aggressive piscivorous feeding habits and are typically utilized in sport fisheries to augment other fish populations in lowland lake settings. When stocked at low densities tiger muskellunge usually do not have a controlling effect on other fish populations (Schriever and Murphy In Prep). A typical stocking rate of tiger muskellunge is approximately 10 fish per hectare of lake surface area. Stocking tiger muskellunge at high densities, such as 40 fish per hectare, however, has been found to eliminate brook trout from high mountain lakes in some cases (Schriever and Murphy In Prep). Tiger muskellunge that escape lakes which they were stocked will likely not survive due to the high gradient streams indicative of north central Idaho headwater areas (Schriever and Murphy In Prep).

Tiger muskellunge were introduced into two high mountain lakes (Ice Lake in the NFCR drainage and Lower Rainbow Lake in the Selway River drainage) in 1998 and 1999 to evaluate their effectiveness at removing brook trout. The success of this program varied largely on the density of tiger muskellunge introduced into the lakes. One lake (Ice Lake) was stocked with a high density of tiger muskellunge (40.7 fish per ha of surface area); and when coupled with the removal of brook trout from lake inlets and outlets by electrofishing, was successful in removing brook trout from the lake. The other lake (Lower Rainbow Lake) was initially stocked with a low density of tiger muskellunge (5.7 fish per ha), and five years later stocked at a high density of 40 fish per ha. Brook trout abundance and their size structure significantly changed in this lake but were not successfully removed.

In the Pahsimeroi River drainage, a similar study was conducted by the Salmon Region in Carlson Lake (2 ha). The brook trout population within Carlson Lake was stunted and the objective of tiger muskellunge introduction was to improve their size structure and to make a more desirable fishery. In 2002, 20.5 tiger muskellunge per ha were introduced to the Lake. By 2006, the goal of the tiger muskellunge stocking was achieved as the brook trout population in Carlson Lake increased in weight and length significantly (Curet et al. 2008). To further evaluate the use of tiger muskellunge as a control or suppressing agent to potentially eradicate brook trout, the IDFG and USFS selected four lakes in the Clearwater Region in which to introduce tiger muskellunge. All four lakes had self-sustaining brook trout populations and fed into tributaries with native bull trout and westslope cutthroat trout. Specifically the objectives of this study were as follows:

OBJECTIVES

1. Evaluate factors that influence the success of tiger muskellunge introductions in reducing or removing brook trout populations from high mountain lakes.

2. Evaluate the use of electrofishing in removing brook trout from inlets, outlets, low gradient sections of stream.

STUDY SITES

Tiger muskellunge were introduced into Fly, Heather, Platinum, and Running lakes. Fly, Heather, and Platinum lakes are located in the Clearwater National Forest and drain into Meadow Creek, a tributary to the upper NFCR fifth field hydrologic unit code (HUC 5) watershed (Appendix I). High densities of bull trout and westslope cutthroat occur in Meadow Creek (Hanson et al., 2006). Fly, Platinum, and Heather lakes grouped together in the Five Lake Butte area are considered a concentrated source population of brook trout that may affect downstream native fish populations. Running Lake is located in the Nez Perce National Forest and drains into Running Creek, a headwater tributary to the Upper Selway River HUC 4 sub-basin drainage (Appendix I). Running Creek also has native bull trout and cutthroat trout (USFWS 1998). Running Lake is considered a large source population of brook trout in the Selway River drainage.

<u>Fly Lake</u>

Fly Lake is situated 7.9 km south of the Five Lakes Butte area and 3.2 km north of Fly hill within the Clearwater National Forest (Appendix J). Fly Lake is located in a cirque type landform with a north-east aspect and is completely surrounded by sub-alpine forest composed mostly of sub-alpine fir *Abies lasiocarpa* and Engelmann spruce *Picea engelmannii* (Appendix K). Fly Lake is at an elevation of 1,652 m, has a maximum depth of 3.3 m and a surface area of 1.02 ha. There is a small amount of woody debris that has collected around the single lake outlet. Fly Lake's littoral zone is composed mainly of silt (Table 5). Fly lake has multiple small inlets that field crews classified as seeps which were composed mainly of silt substrates (Table 6). The single outlet to Fly Lake (situated on the northeast shore of the lake) drains into a high gradient unnamed stream and has a substrate dominated by boulders and rubble (Table 7). The unnamed stream formed by the Fly Lake outlet converges with Meadow Creek 11.7 km upstream from the confluence of Meadow Creek and the upper NFCR. The route used to access Fly Lake can be referenced in Appendix J.

Heather Lake

Heather Lake is located in the Five Lakes Butte Area within the Clearwater National Forest (Appendix J). Heather Lake is located in a low cirque type landform with a north-west aspect and is surrounded by sub-alpine forest and Idaho granitic bedrock batholithic outcroppings (Appendix K). Heather Lake is located at an elevation of 1,875 m, has a maximum depth of 9.0 meters, and a surface area 2.62 ha. The littoral zone in Heather Lake is composed mainly of silt (Table 5). There are two inlets to Heather Lake. The major inlet has substrate dominated by silt, sand, and gravel (Table 6). The main outlet to Heather Lake is located on the southwest side of the lake. The outlet at Heather Lake may be seasonally dry and has a dominant substrate of silt (Table 7). The unnamed creek draining Heather Lake's main outlet converges with Meadow Creek at 23.3 km from the confluence of Meadow Creek and the upper NFCR. The route used to access Heather Lake can be referenced in Appendix J.

Platinum Lake

Platinum Lake is located in the Five Lakes Butte Area within the Clearwater National Forest (Appendix J). Platinum Lake is located in a cirque type landform with a northeast aspect and is surrounded by sub-alpine forest, Idaho granitic bedrock batholithic outcroppings, and talus slopes (Appendix K). Platinum Lake is at an elevation of 1,753 m, has maximum depth of 4.1 m, and a surface area of 1.00 ha. The littoral zone in Platinum Lake is composed of mainly silt (Table 5). Platinum Lake has multiple small inlets (seeps) and one main outlet that are dominated by rubble and silt composition (Tables 6 and 7). The main inlet and outlet to Platinum Lake are low gradient. The main outlet to Platinum Lake is situated on the north shore of the lake and drains into an unnamed stream which flows into the upper headwaters of Meadow Creek at 19.7 km from the confluence of Meadow Creek and the upper NFCR. Platinum Lake has a moderate amount of woody debris which has collected mostly around the main inlet and outlet of the lake in the form of submerged logs. The route used to access Platinum Lake can be referenced in Appendix J.

Running Lake

Running Lake is situated 2.8 km south of Bilk Mountain in the Nez Perce National Forest (Appendix J). Running Lake is located in a cirque landform with a northeast aspect and is surrounded by sub-alpine forest, talus slopes, and bedrock outcroppings (Appendix K). Running lake is located at an elevation of 2,008 m, has a maximum depth of 14.0 m, and a surface area of 8.4 ha. The littoral zone in Running Lake is composed mainly of gravel (Table 5). The inlet at Running Lake is dominated by a silt substrate (Table 6). The main outlet draining Running Lake is on the northeast side of the lake and is composed of silt and gravel substrate with LWD also concentrated around the outlet (Table 7). The unnamed creek from Running Lake converges with Running Creek 38.1 km upstream from the confluence of Running

Creek and the Upper Selway River. The route used to access Running Lake can be referenced in Appendix J.

METHODS

Brook trout population estimates were conducted on each lake prior to stocking of tiger muskellunge. Mark and recapture population estimates were made using the adjusted Petersen estimate (Ricker 1975). Brook trout were initially collected using hook and line sampling and marked with an adipose fin clip. Angling was conducted from both shore and by float tube, using a variety of angling tackle and bait. After marking brook trout, two 40 m gill nets were set overnight (approximately 12 hours) to recapture marked fish and document baseline CPUE and length frequencies to compare with future net sets. Gill nets used were multi-meshed experimental nets containing three mesh sizes from 10 to 38 mm. Total length and weight were recorded for all fish captured (field crews did not record brook trout weights on Running Lake in 2006 or 2007 and Heather Lake in 2004). All brook trout captured in gill nets were discarded after length and weight measurements were recorded. The brook trout population estimate was for all fish sizes collected in gill nets, and we assumed gill nets sample brook trout size in proportion to their availability. The CPUE and length frequencies of brook trout gill netted in 2006 represented baseline conditions of pre tiger muskellunge introductions. The CPUE and length frequencies from these monitoring efforts will represent the manner in which change in brook trout population structure will be measured.

Tiger muskellunge were obtained from the IDFG Hagerman Hatchery and transported to locations on the NFCR and Selway Rivers. Most tiger muskellunge stocked in 2006 were > 250 mm in order to decrease their vulnerability to predators and increase first year over-winter survival. Fire suppression helicopters from the USFS with water buckets were employed to stock the tiger muskellunge into high mountains lakes (Fly, Platinum, Heather, and Running). Tiger muskellunge were transported in loads of 20 to 50 fish per 100 gallon fire bucket. Helicopter pilots transporting tiger muskellunge to mountain lake locations were provided with GPS coordinates by the IDFG. All tiger muskellunge were stocked on June 29, 2006 at a density of approximately 40 fish/ha. Post stocking mortality is a concern with tiger muskellunge and lower survival occurs from abrupt temperature changes, handling, confinement, and stocking stress (Mather and Wahl 1989; Hanson and Margenau 1992). Thus, it is assumed that the stocking rate of 40 tiger muskellunge/ha was initially reduced by post stocking mortality.

Fly, Platinum, Heather, and Running lakes were all gill netted in 2009 using the same methodology as employed in 2006, 2007, and 2008. Mean ranked lengths from length frequency distributions of brook trout gill netted in 2009 were compared to the mean ranked lengths from length frequency distributions of brook trout gill netted prior to tiger muskellunge introductions in 2006 and each year post tiger muskellunge introduction (2007 and 2008). In each lake, the length frequency distributions were compared among years using a Kruskal-Wallis test, which is a ranked based ANOVA for multiple samples (significant differences were determined at the $\alpha = 0.05$ level). All statistical comparisons were conducted using procedures in SAS version 9.1 (SAS 1999). If significant differences were found among years, then pairwise comparisons were made using Tukey's multiple-range test, to determine which years differed significantly in mean ranked length.

Effects of CPUE were assessed by performing linear regressions, with CPUE as the dependent variable and time as the independent variable (predictor variable). Effects were measured by testing whether the slope equaled zero, indicating no change (significant differences were determined at the $\alpha = 0.05$ level). From the linear regression we can determine general trends, direction/rate of change, and strength of the CPUE and time relationship (Ney 1999).

Relative weight as a condition factor can be used to monitor influence of anthropogenic manipulations over time (Ney 1999). Relative weights for brook trout were determined using the index developed by Wege and Anderson (1978). The standard weight used in the equation was proposed for brook trout populations by Whelan and Taylor (1984). We opted not to use the slope from our $\log_{10}$length $\log_{10}$weight regressions for the standard weight because for most years as they were less than three and maybe inappropriate for use to determine relative weights (Carlander, 1969; Murphy et al. 1991). A slope of less than three may be a result of brook trout populations that are in a stunted condition or include small fish in the sample (Carlander 1969). Small fish were included in mean W_r and W_r histograms because samples were increasingly small each year. A histogram of W_r was developed for each lake and year where weight data was available. Relative weight histograms are incomplete for Heather (2004) and Running (2006 and 2007) lakes as field crews did not record weights of brook trout from these samples.

Field personnel must return to these four lakes for three to five years following tiger muskellunge introductions and continue gill net sampling to evaluate how brook trout populations have changed (CPUE and length frequencies). Lakes identified with inlets and outlets that have suitable brook trout spawning habitat and or rearing habitat may require electrofishing to remove any brook trout that utilize these areas. Physical attributes of each lake including littoral zone composition, inlet characteristics, and outlet characteristics will be documented through visual observations (Appendix L). These variables will be compared to changes in brook trout CPUE and length frequency to assess their influence of tiger muskellunge introductions in eliminating or suppressing brook trout within the four lakes.

RESULTS

Personnel from IDFG and USFS sampled brook trout populations in Fly, Platinum, Heather, and Running lakes in 2009. This was the third year of evaluating the brook trout populations in these lakes following tiger muskellunge stocking.

Fly Lake

Tiger muskellunge were stocked into Fly Lake on June 29, 2006 at a density of 40 fish/ha. On June 23, prior to tiger muskellunge stocking, a brook trout population evaluation was conducted, and it was determined there were 299 brook trout ranging in length from 109 to 274 mm with a mean total length of 231 mm (Figure 9; Tables 8, 9, and 10). The catch rate (CPUE) determined by an overnight gill net set on June 23, 2006 was 5.33 brook trout/hr (Figure 10; Table 10). An overnight gill net set (15 hr) on June 28, 2007 was used to determine status of brook trout in Fly Lake one year after stocking tiger muskellunge. In 2007, gill netting efforts captured 20 brook trout ranging from 255 - 297 mm with a mean total length of 274 mm (Figure 9; Table 10). The CPUE for brook trout in 2007 was 1.3 fish/hr, about 4.0 times lower than what was observed in 2006 (Figure 10; Table 10). An overnight gill net set (17.25 hr) on July 17, 2008 was used to determine the status of brook trout in Fly Lake approximately two years after the introduction of tiger muskellunge. In 2008, gill netting efforts captured 10 brook trout ranging from 253 to 304 mm in total length (with a mean total length of 285 mm) and no tiger muskellunge (Figure 9; Table 10). The CPUE for brook trout in 2008 was 0.58 fish/hr, about 9.1 times lower than was observed in 2006 and about 2.5 times lower than was observed in 2007 (Figure 10; Table 10).

An overnight gill net set (20.70 hr) on July 27, 2009 was used to determine the status of brook trout in Fly Lake approximately three years after the introduction of tiger muskellunge. In 2009, gill netting efforts captured no (zero) brook trout or tiger muskellunge (Table 10). Accordingly, the CPUE for brook trout in 2009 was 0.0 fish/hr (Figure 10; Table 10). No tiger muskellunge were observed during a search of the littoral zone of Fly Lake. No trout fry were observed in the inlets, outlet, or littoral zones of Fly Lake in 2009.

The CPUE vs. time regression showed a decreasing slope for 2006-2009 (Figure 10). The slope of the CPUE vs. time regression was not significantly different than zero ($p=0.103$); however, power to detect significant differences were low due to little repetition in sampling events (Fly lake sampled once each year, consecutively for four years).

Brook trout lengths and weights (minimum, maximum, and average) increased from 2006 to 2008 in Fly Lake (Figure 9; Tables 10 and 11). The histograms of brook trout relative weights show a general shift toward a higher condition factor following tiger muskellunge introductions (Figure 11). Kruskal-Wallis testing showed that there were significant differences between the mean ranked length among each of the years between 2006 and 2008 ($p<0.001$). Pairwise comparisons using Tukey's multiple-range tests showed that 2006 was significantly different than 2007 and 2008; however, no significant differences existed between 2007 and 2008 (Table 12). Relatively small sample sizes of brook trout from Fly Lake, especially in 2007 and 2008 likely impacts the power of the Kruskal-Wallis and Tukey's multiple-range tests to accurately detect differences. Comparisons between mean ranked lengths could only be made between 2006, 2007, and 2008, as no brook trout were captured in 2009 gill netting efforts.

Heather Lake

Tiger muskellunge were stocked into Heather Lake on June 29, 2006 at a density of 40 fish/ha. Ice coverage prior to June 29 prevented personnel from evaluating the brook trout population immediately prior to tiger muskellunge introductions. Consequently, data collected previously in 2004 were used to represent pre tiger muskellunge baseline brook trout conditions. No brook trout population estimate was made in 2004 due to the inability to recapture marked fish. An overnight gill net set (12.5 hr) on October 31, 2004 captured eight brook trout resulting in a CPUE of 0.64 fish/hr (Figure 10; Tables 9 and 10). Total lengths of brook trout captured in 2004 ranged from 142 to 353 mm with a mean total length of 309 mm (Figure 12; Table 10). An overnight gill net set (16 hr) on June 27, 2007 was used to determine the status of brook trout in Heather Lake approximately one year after stocking tiger muskellunge. Gill netting efforts captured 16 brook trout and no tiger muskellunge in 2007. Total lengths of brook trout captured in 2007 ranged from 218 mm to 374 mm with a mean total length of 322 mm (Figure 12; Table 10). The CPUE for brook trout in 2007 was 1.0 fish/hr which was about 1.6 times higher than observed in 2004 (Figure 9; Table 10). An overnight gill net set (18 hr) on July 17, 2008 was used to determine the status of brook trout in Heather Lake approximately two years after the introduction of tiger muskellunge. Gill netting efforts captured 13 brook trout ranging 317 to 366 mm in total length with a mean total length of 343 mm (Figure 12; Table 10). The CPUE for brook trout in 2008 was 0.72 fish/hr which was 1.1 times higher than observed in 2004 but 1.4 times lower than was observed in 2007 (Figure 10; Table 10). No tiger muskellunge were gill netted or observed after visually searching the entire littoral zone of the lake in 2008.

An overnight gill net set (21.9 hr) on July 27, 2009 was used to determine the status of brook trout in Heather Lake approximately three years after the introduction of tiger muskellunge. Gill netting efforts captured four brook trout ranging in size from 325 to 343 mm with a mean total length of 337 mm (Figures 12; Table 10). The CPUE for brook trout in 2009 was 0.18 fish/hr approximately 3.5 times lower than was observed in 2004, 5.5 times lower than observed in 2007, and 4.0 times lower than observed in 2008 (Figure 10; Table 10). No tiger muskellunge were observed in a search of the littoral zone of the lake. However, brook trout adults and fry were observed in the inlet of the lake in 2009. The CPUE vs. time regression showed a decreasing slope for 2006 - 2009 (Figure 10). The slope of the regression was not significantly different than zero (p=0.619); however, power to detect significant differences were low due to little repetition in sampling events (Heather Lake sampled once each year, in 2004 and consecutively for three years from 2007 - 2009).

Minimum brook trout lengths and weights increased from 2004 to 2009 in Heather Lake (Figure 12; Tables 10 and 11). Maximum brook trout lengths and weights initially increased post tiger muskellunge introduction but more recently have been decreasing since 2007 (Figure 12; Tables 10 and 11). Average brook trout lengths and weights initially increased until 2008 and then decreased in 2009 (Figure 12; Tables 10 and 11). The histograms of brook trout relative weights show a general shift toward a higher condition factor following tiger muskellunge introductions (Figure 13; Table 11). Kruskal-Wallis testing showed that there were no significant differences between the mean ranked length of brook trout among each of the years (p=0.400). Relatively small sample sizes of brook trout from Heather Lake, throughout 2004 - 2009 likely impacts the power of the Kruskal-Wallis test to accurately detect significant differences.

Platinum Lake

Tiger muskellunge were stocked into Platinum Lake on June 29, 2006 at a density of 40 fish/ha. On June 24-25, 2006 prior to tiger muskellunge stocking, a brook trout population evaluation was conducted, and it was determined there were 148 brook trout ranging in length from 128 to 300 mm with a mean total length of 220 mm (Figure 14; Tables 8, 9, and 10). The catch rate determined by an overnight gill net set on the night of June 25, 2006 was 3.00 brook trout/hr (Figure 10; Table 10). An overnight gill net set (14 hr) on June 26, 2007 was used to determine the status of brook trout in Platinum Lake one year after stocking tiger muskellunge. In 2007, gill netting efforts captured 11 brook trout ranging in length from 241-332 mm with a mean total length of 294 mm (Figure 14; Table 10). The CPUE for brook trout in 2007 was 0.79 fish/hr approximately 3.8 times lower than was observed in 2006 (Figure 10; Table 10). No tiger muskellunge were gill netted or observed after visually searching the entire littoral zone of the Platinum Lake in 2007. Trout fry were observed in the main outlet from Platinum Lake in 2007. An overnight gill net set (18.5 hr) on July 17, 2008 was used to determine the status of brook trout approximately two years after the introduction of tiger muskellunge. In 2008, gill netting efforts captured 19 brook trout ranging in size from 114 to 353 mm with a mean total length of 203 mm (Figure 14; Table 10). The CPUE for brook trout in 2008 was 1.03 fish/hr which was about 2.9 times lower than was observed in 2006, and about 1.3 times higher than was observed in 2007 (Figure 10; Table 10). No tiger muskellunge were gill netted or observed after visually searching the entire littoral zone of the Platinum Lake in 2008, and a single trout fry was observed near the outlet of platinum lake.

An overnight gill net set (21.5 hr) on July 28, 2009 was used to determine the status of brook trout approximately three years after the introduction of tiger muskellunge. In 2009, gill netting efforts captured 13 brook trout ranging in size from 128 to 377 mm with a mean total length of 231 mm (Figures 14 and 18; Table 10). No tiger muskellunge were captured in 2009 gill nets. The CPUE for brook trout in 2009 was 0.60 fish/hr approximately 5.0 times lower than was observed in 2006, 1.3 times lower than was observed in 2007, and 1.7 times lower than was observed in 2008 (Figure 10; Table 10). No tiger muskellunge were observed during a littoral zone search of the lake. However multiple brook trout fry were observed during the littoral zone search in 2009. The CPUE vs. time regression showed a decreasing slope for 2006-2009 (Figure 10). The slope of the regression was not significantly different than zero ($p=0.191$); however, power to detect significant differences were low due to little repetition in sampling events (Platinum Lake sampled once each year, consecutively for four years).

Minimum brook trout lengths and weights initially increased from 2006 to 2007, then decreased from 2007 to 2008, and subsequently increased from 2008 to 2009 (Figure 14; Tables 10 and 11) . Maximum brook trout lengths and weights present an increasing trend from 2006 to 2009 (Figure 14; Tables 10 and 11). Both the average length and weight of brook trout increased from 2006 to 2007, decreased in 2008 and remained similar in 2009 in Platinum Lake (Figure 14; Tables 10 and 11). The histograms of brook trout relative weights show a general shift toward a higher condition factor from 2006 to 2007, a decrease in W_r in 2008, then increased in 2009 (Figure 15; Table 11). Kruskal-Wallis testing showed that there were significant differences between the mean ranked length of brook trout among each of the years ($p=0.003$). Pairwise comparisons using Tukey's multiple-range tests showed that mean ranked lengths of brook trout in 2007 were significantly different from those in 2006 and 2008 with no significant differences occurring between 2006 and 2008 (Table 12). Pairwaise comparisons using Tukeys's multiple-range tests showed that mean ranked lengths of brook trout in 2009 were not significantly different from those in 2006, 2007, or 2008 (Table 12). Relatively small sample sizes of brook trout from Platinum Lake, throughout 2004-2009 likely impacts the power of the Kruskal-Wallis and Tukey's multiple-range tests to accurately detect significant differences.

Running Lake

Tiger muskellunge were stocked into Running Lake on June 29, 2006 at a density of 41.6 fish/ha. On June 28-29, 2006, prior to tiger muskellunge stocking, a brook trout population evaluation was conducted, and it was determined there were 3,389 brook trout ranging in length from 100 to 225 mm with a mean total length of 181 mm (Figure 16; Tables 8, 9, and 10). The catch rate determined by an overnight gill net set on the night of June 28, 2006 was 5.31 brook trout/hr (Figure 10; Table 10). Two overnight gill netting efforts (19 hr and 12 hr) on July 23 and 25, 2007 were used to determine the status of brook trout in Running Lake one year after stocking tiger muskellunge. In 2007, gill netting efforts captured 120 brook trout ranging in length from 102 to 220 mm with a mean total length of 190 mm (Figure 16; Table 10). The CPUE for brook trout in 2007 was 3.9 fish/hr approximately 1.4 times lower than was observed in 2006 (Figure 10; Table 10). No tiger muskellunge were gill netted or observed in the littoral zone of the lake in 2007. An overnight gill net set (19.75 hr) on July 24, 2008 was used to determine the status of brook trout in Running Lake, two years after tiger muskellunge introductions. Gill netting efforts captured 67 brook trout ranging from 91 to 264 mm with a mean total length of 191 mm (Figure 16; Table 10). The CPUE for brook trout in 2008 was 3.39 fish/hr which was about 1.6 times lower than was observed in 2006 and about 1.1 times lower than was observed in 2007 (Figure 10 and Table 10). No tiger muskellunge were gill netted in 2008; however, tiger muskellunge were observed after visually searching the littoral zone of Running Lake.

An overnight gill net set (22.9 hr) on September 3, 2009 was used to determine the status of brook trout in Running Lake, approximately three years after tiger muskellunge introductions. Gill netting efforts captured 145 brook trout ranging in size from 105 to 295 mm with a mean total length of 162 mm (Figures 16 and 18; Table 10). The CPUE for Running Lake brook trout in 2009 was 6.33 fish/hr approximately 1.2 times higher than was observed in 2006, 1.6 times higher than observed in 2007, and about 1.9 times higher than observed in 2008 (Figure 10; Table 10). The CPUE vs. time regression showed an increasing slope for 2006-2009 (from 2006 up to 2008 the slope of this regression had been decreasing) (Figure 10). No tiger muskellunge were observed in a search of the littoral zone of the lake. However, multiple brook trout fry were observed during this search. The slope of the regression was not significantly different than zero (p=0.753); however, power to detect significant differences were low due to little repetition in sampling events (Running Lake sampled once each year, consecutively for four years).

Minimum brook trout lengths have fluctuated (14 mm) from 2006 to 2009 (Figure 16; Table 10). Maximum brook trout lengths have increased from 2006 to 2009 (Figure 16; Table 10). The average length of brook trout increased from 2006 to 2007 then remained similar in 2008 and subsequently decreased in 2009 (Figure 16; Table 10). Although the mean length of brook trout was similar in Running Lake between 2007 and 2008, there was a shift to both larger and smaller sized fish in 2008, then a general shift toward smaller length fish in 2009 (Figure 16; Table 10). Brook trout weights were not recorded in 2006 or 2007; consequently, shifts in weights or W_r could not be evaluated for those years (Table 11). The average W_r decreased from 2008 to 2009 (Figure 17; Table 11).

Kruskal-Wallis testing showed that there were significant differences between the mean ranked length of brook trout among each of the years (p<0.0001). Pairwise comparisons using Tukey's multiple-range tests showed that mean ranked lengths were significantly different between 2006 and 2008, but not was not significantly different than 2007 (Table 12). Pairwise comparisons using Tukey's multiple-range tests showed that mean ranked lengths in 2009 were significantly different than 2006, 2007, and 2008 (Table 12).

DISCUSSION

The general CPUE trend of brook trout decreased from pre tiger muskellunge introduction levels in three of four high mountain lakes (Fly, Heather, and Platinum lakes) containing self-sustaining brook trout populations three years after tiger muskellunge were stocked. Gill netting efforts on Fly Lake captured no brook trout indicating that brook trout have been successfully removed from this lake. Length frequency and relative weights of brook trout in Heather Lake continued to generally shift toward larger sized fish and smaller sample sizes of brook trout (four brook trout were captured from Heather Lake in 2009). The likely reason for the increase in density of larger sized brook trout in Heather Lake was predation by the tiger muskellunge initially targeting smaller sized brook trout (< 250 mm) coupled by a release in intraspecific competition. The first year following introductions, most tiger muskellunge were < 450 mm and the second year most were estimated to be < 550 mm. Tiger muskellunge tend to feed on prey 25-43% their body length (Wahl and Stein 1988). As of 2009 tiger muskellunge that remain in these lakes are likely ≥ 650 mm and can target most size classes of brook trout that remain within the lakes and as brook trout availability decreases tiger muskellunge will likely prey upon any size classes of brook trout that remain. Schriever and Murphy (In Prep) also found that the average size of brook trout increased in high mountain lakes after tiger muskellunge introductions as they tended to target brook trout < 250 mm. As tiger muskellunge grow, they will prey upon increasingly larger brook trout and should be able to influence all size classes of brook trout in these lakes. We expect by the fourth year of this study (2010) that tiger muskellunge will be able to target all sizes of brook trout available in the lakes. In Running Lake (2009) many of the smaller brook trout still exist and are abundant. There is a concern that as the tiger muskellunge grow they will target the larger brook trout allowing the smaller brook trout to flourish. If the tiger muskellunge are able to crop off the larger brook trout, in this case, it is unknown whether they would be effective in removing the abundant smaller brook trout after larger prey become limited or unavailable.

In Fly Lake, the general trend of CPUE decreased throughout those years post tiger muskellunge introduction, from 5.3 fish/hr in 2006 (just prior to tiger muskellunge introductions) to effectively zero fish/hr in 2009. Coupled with the general decline in brook trout CPUE, was the general increases in lengths, weights, and relative weight condition factors (2007-2009). Tiger muskellunge presence was confirmed in Fly Lake each year post introduction either through gill netting efforts or visual observations of littoral zones except for 2009. It is suspected that after tiger muskellunge effectively depleted prey items within the lake, they subsequently died off or decreased to a level that is undetectable by visual observation or gill netting. Furthermore no indications of brook trout spawning were observed in 2009 (presence of brook trout fry) as had been documented (at low levels) in all previous surveys of this lake post tiger muskellunge introduction (2007 and 2008). The effectiveness of tiger muskellunge to eliminate brook trout from Fly Lake is likely dependent on factors that include the confirmed presence of tiger muskellunge in 2007 and 2008 (overwinter survival), perceived low visitor usage of Fly Lake (low to no harvest of tiger muskellunge), moderately small lake size and suitable lake depth (allowing for encounters between book trout and tiger muskellunge), seep type inlets not suitable for spawning, a relatively short outlet dominated by boulders and rubble with minimal spawning areas, high gradient sections of stream below the lake itself (likely an upstream barrier to brook trout), and large woody debris in the littoral zone of the lake providing tiger muskellunge with areas from which to ambush brook trout.

In Heather Lake, the general trend of CPUE increased from 2004 (pre tiger muskellunge introductions) to 2007 and then continued to decrease from 2007 through 2009 sampling events. Heather Lake was the only lake not surveyed in 2006 due to ice. Consequently, data collected in the fall of 2004 was used to portray brook trout CPUE and size structure pre-tiger muskellunge introductions. This CPUE data could be misleading as effort was light (one net), the sample size was small (8 fish), and sampling occurred during the fall when many brook trout could have been spawning in tributaries. If CPUE data from 2004 is not used, the data from 2007, 2008, and 2009 would suggest that brook trout densities are declining from pre-tiger muskellunge levels in Heather Lake. The length frequency and relative weight data supports this reasoning as the brook trout are attaining larger lengths and higher relative weight condition factors. Gill netting efforts in 2009 captured no brook trout smaller than 325 mm, though a single fry was observed near the outlet of Heather Lake. No tiger muskellunge were observed or sampled in 2009 in Heather Lake although the brook trout length frequency and relative weight data would suggest that they were still present.

In Platinum Lake, the general CPUE trend initially decreased (2007) after tiger muskellunge were introduced, but remained constant from 2007 to 2009. Length frequencies, weights, and W_r condition factors also followed similar patterns. Based on this data, many of the tiger muskellunge in this lake may have died between the 2007 and 2008 sample period. Some tiger muskellunge likely still inhabit Platinum Lake as evidenced by the decline of brook trout CPUE in 2009 and decline in younger age classes between 2008 and 2009. Likely reasons for this die off include over winter kill and/or excessive angler harvest. Access to Platinum Lake is not difficult, there is no established trail to the lake, and visitor usage appears to greater than that of Fly Lake (based on the amount campsites). Platinum Lake is relatively shallow (4.1 m) and is at an elevation (1,753 m) susceptible to freezing over for extended periods of time (~ five to six months). The winter of 2007 - 2008 had above average snow pack for the area and lakes in the Five Lakes Butte area were still frozen over in late June 2008. We are unaware of whether tiger muskellunge are more susceptible to winter kill than brook trout as brook trout abundance increased after the winter of 2007 - 2008.

In Running Lake, brook trout CPUE decreased post tiger muskellunge introduction until 2008, then subsequently doubled between 2008 and 2009 to the point that brook trout CPUE was higher than the pre tiger muskellunge level observed in the 2006 sampling event. Average lengths, weights, and relative weights also declined between 2008 and 2009. This suggests that tiger muskellunge no longer exist at high enough densities to suppress brook trout abundance. No tiger muskellunge were observed in the littoral zone of Running Lake in 2009, although large tiger muskellunge (~500 - 550 mm) were observed in 2008 in visual searches. If tiger muskellunge still occur in Running Lake in 2009 they would likely be ≥ 650 mm. These large tiger muskellunge are likely preying upon brook trout ~162 to 280 mm and may only occasionally target smaller younger fish. The inability of tiger muskellunge to reduce small size classes of brook trout in Running Lake as was observed in other lakes may be due the overall abundance of brook trout at larger size classes that larger tiger muskellunge may prefer to select as prey. Tiger muskellunge likely only target smaller sized brook trout after densities of larger brook trout have been reduced. Thus the effectiveness tiger muskellunge to reduce recruitment may decrease as tiger muskellunge become larger and target larger sized brook trout. Running Lake is a relatively deep mountain lake and it is likely that overwintering areas within the lake are abundant, thus a large over winter kill of tiger muskellunge is not suspected to have occurred in this lake. Running Lake also has a large gravel alluvial fan extending from the inlet that may provide spawning areas in addition to inlet and outlet areas. There in a concern that excessive fishing pressure may have reduced the tiger muskellunge stocked in Running Lake. Ease of access to Running Lake and the lakes popularity, facilitates numerous visitors each year.

No tiger muskellunge were sampled during our 2009 gill netting or observed through visual searches of the entire littoral zone of each lake. As explained by Hanson et al. (1986), sampling of tiger muskellunge after a stocking event can be difficult because of their ability to escape capture by gill nets. Field crews in 2007 observed that tiger muskellunge were likely being caught in the gill net but were freeing themselves from the net by tearing holes with their sharp teeth and gill rakers. The packable high mountain lake gill nets are constructed of fine monofilament making them susceptible to tearing. To verify the presence of tiger muskellunge in all four lakes field crews had to rely on observations of tiger muskellunge from the littoral zone or by means of angling. At Platinum Lake in 2007 no tiger muskellunge were observed through a littoral zone search or in the gill net, but when the gill net was pulled the next morning many new small holes in the gill net were observed.

It is likely that the effectiveness of tiger muskellunge to control brook trout may be increased or occurs quicker in relatively small lakes (< 1 ha) with short inlets and outlets that would provide minimal refuge for brook trout (Schriever and Murphy In Prep; Knapp and Matthews 1998). Running Lake (8.4 ha) is the largest of the lakes we sampled and changes in brook trout CPUE and size structure was not as pronounced as in the smaller mountain lakes (Fly, Platinum, Heather lakes) we evaluated. Smaller, shallower lakes may improve the effectiveness of tiger muskellunge to control brook trout, especially during winter months when prey and predator may be confined to a small area within the lake.

Larger lakes may offer a wider range in habitat complexity which could decrease the effectiveness of tiger muskellunge predation on brook trout. Schriever and Murphy (In Prep) postulated that an absence of wood and emergent vegetation would increase the effectiveness of tiger muskellunge predation on brook trout. However, studies by Tomocko et al. (1984) have shown that absence or presence of vegetation did not influence tiger muskellunge predation on bluegill. Studies by Hanson and Margenau (1992) found that radio tagged tiger muskellunge generally selected inshore habitat areas that were less than ten feet deep, with emergent or submerged vegetation, and woody debris. In addition, similar studies within other IDFG Regions have concluded that hiding cover provided by woody debris and aquatic vegetation may increase the effectiveness of tiger muskellunge to prey upon brook trout as this hiding cover allows area from which tiger muskellunge can ambush brook trout (M. Koenig, IDFG, personal communication). Based on these findings it would lead us to believe that in larger and deeper lakes where there is more open water habitat, feeding by an ambush predator like tiger muskellunge would be less effective. Finally, larger lakes may be able to support more brook trout, with different size class structures and significant changes in populations may not be observed as quickly as in smaller mountain lakes. The changes in brook populations (little to no recruitment, more obvious shifts in size class structure and CPUE) that were observed after two years in smaller mountain lakes may take a longer period to observe similar results in larger mountain lakes.

Tomcko et al. (1984) has indicated that prey density can have more of an influence than prey size on the ability of tiger muskellunge to eradicate fish from a lake. If this is the case, tiger muskellunge would be less effective in eradicating brook trout in Running Lake which had the highest density of brook trout of the lakes that were surveyed in 2006. Our data supports this as after the first year, Running Lake was the only lake where brook trout < 200 mm were sampled. This type of information would suggests that when stocking tiger muskellunge into lakes to eradicate brook trout that one should adjust stocking densities based both upon the size of the lake and the number of brook trout that are estimated to occur in the lake.

The length of a high mountain lakes inlet and outlet may also dictate how effective tiger muskellunge are in reducing/removing brook trout. Longer inlets and outlets may provide more area for brook trout to take refuge from tiger muskellunge and increase spawning success. Inlets and outlets that are seasonally dry may force brook trout to inhabit lakes with tiger muskellunge. In addition, inlets and outlets with little flow may freeze completely during winter also forcing brook trout to inhabit lakes with tiger muskellunge. High mountain lakes with longer inlets and outlets with significant permanent flow may also require electrofishing removal efforts to make brook trout eradication possible. Heather Lake and Running Lake both have inlets 20 to 100 m in length with permanent flow. These inlets may require electrofishing for brook trout eradication to be successful. Fly and Platinum lakes have only small seep type inlets and will likely not require any electrofishing in these areas. Due to the outlet length, flow and the absence of barriers, the outlet from Platinum Lake may require electrofishing for brook trout eradication to be successful (Table 7). Low gradient sections of stream below Heather, Platinum, and Running lakes have been identified that may contain brook trout that may also require electrofishing for brook trout eradication to be successful. It is unclear if fish can migrate from these low gradient reaches upstream into the lakes during different flow conditions. Fly

Lake has mostly high gradient sections of stream below the lake that is an upstream barrier to fish.

It is not clear what influence tiger muskellunge introductions had on spawning success as age-0 brook trout are not recruited to the gill nets. However, it is suspected that brook trout attempting to spawn along shore would be harassed or preyed upon by tiger muskellunge. The spawning behavior of brook trout that spawned in tributaries or outlets would likely not be influenced by tiger muskellunge as they are not known to enter small streams. It may be necessary to combine tiger muskellunge stocking with tributary electrofishing removal efforts to eradicate brook trout from lakes with suitable spawning tributaries. Schriever and Murphy (In Prep) were able to eradicate brook trout from a high mountain lake after four years with a combination of tiger muskellunge introductions and tributary electrofishing removal.

The qualitative removal potential criterion developed by Kozfkay and Koenig (2006) helps to simplify the lake morphological characteristics that likely aid tiger muskellunge in eliminating or suppressing brook trout populations in mountain lakes. The criteria are as follows: success of elimination is likely very high if lakes have no inlets or outlets with spawning habitat and lakes have low habitat complexity; success of elimination is high if lakes have only limited spawning areas within outlets or inlets and have migration barriers; success is likely moderate if lakes contain some available spawning areas in inlets or outlets; success is likely low if lakes contain abundant spawning areas in inlets or outlets, outlets have low gradients sections of spawning areas, and few to no barriers exist where brook trout are established. Based on the removal potential criterion, Fly Lake ranks a very high potential for brook trout to be eliminated, Heather and Platinum Lakes rank at a high potential for brook trout to be eliminated, and Running Lake ranks a low potential for brook trout to be eliminated. This removal potential criteria does not include lake size and depth which also appear to influence success, with larger deeper lakes reducing the ability to tiger muskellunge to suppress brook trout.

Lack of sampling repetition within a single year likely impacts the power of CPUE vs. time regression to accurately detect significant differences. At this time budgetary and time constraints will not allow for multiple sampling events of the same lake within the same year. Small sample sizes of brook trout from Fly, Heather, and Platinum lakes likely impacts the power of the Kruskall-Walis test to detect significant differences. This situation may be inevitable as the goal is to eradicate brook tout from these mountain lakes, decreasing the brook trout population each year after tiger muskellunge introductions, and decreasing subsequent annual sample size. Furthermore gill netting efforts themselves acts to decrease the brook trout population within each lake and the objective of this project is to evaluate the effectiveness of tiger muskellunge at reducing and/or removing brook trout from mountain lakes and not to necessarily evaluate the effectiveness of gill netting removal depletion efforts themselves.

Multiple years of sampling post tiger muskellunge introduction will allow for reinforcement that change in/eradication of brook trout populations can be attributed to tiger muskellunge introductions at stocking densities of around 40 fish/ha. This was the fourth year of our study (third year post tiger muskellunge introductions). In previous work by Schriever and Murphy (In Prep), it took four years to eradicate brook trout from a 0.54 ha high mountain lake after tiger muskellunge were introduced. Larger lakes may take longer for total brook trout eradication to occur.

MANAGEMENT RECOMMENDATIONS

1. Continue monitoring brook trout populations in lakes stocked with tiger muskellunge until 2011 to evaluate their effectiveness at removing brook trout from lakes.

2. Conduct lake inlet and outlet surveys stocked with tiger muskellunge to evaluate whether brook trout spawning is occurring. Based on these surveys, prioritize tributaries for brook trout removal.

3. Engage in brook trout removal efforts in inlets and outlets of Fly and Heather Lakes.

4. Further assess the lake littoral zones and aspects of lake depth/size to evaluate factors that may influence success of tiger muskellunge in eradicating brook trout.

5. Find a consistent, reliable, and safe source of hatchery tiger muskellunge to use as a biological control agent in lakes where it is believed that brook trout eradication would be successful.

6. In future stocking events of tiger muskellunge as a biological control agent of brook trout, adjust stocking density for both lake surface area and density of brook trout determined from population estimations.

7. Continue gill netting Fly Lake and electrofishing from lake outlet to upstream barrier to confirm any brook trout presence (to confirm brook trout eradication has been succesful.

ACKNOWLEDGEMENTS

Funding for 2009 biological control of brook trout using tiger muskellunge was a shared effort between IDFG, Clearwater Region and USFS, Clearwater and Nez Perce National Forests. IDFG and USFS personnel cooperated on sampling of lakes in the Five Lakes Butte area in the Clearwater National Forest. Field personnel that aided in 2009 biological control of brook trout using tiger muskellunge on the Clearwater National Forest include; Dave Schoen and Andre Snyder from the USFS (Clearwater National Forest), Amadeus Guy from the USFS (Nez Perce National Forest, Red River Ranger District), and Tim Kuzan from the IDFG, Clearwater Region. John Erhardt provided guidance on the statistical analysis.

Table 5. The littoral zone composition of lakes stocked with tiger muskellunge in 2006 within the Clearwater Region.

Lake name	% Bedrock	% Boulder	% Rubble	% Gravel	% Sand	% Silt	% Organic debris	% Logs
Fly	0	0	0	0	0	60	0	40
Heather	20	10	5	5	5	55	0	0
Platinum	0	10	5	0	0	65	0	20
Running	0	10	0	50	10	15	10	5

Table 6. Major inlet characteristics of lakes stocked with tiger muskellunge in 2006 in the Clearwater Region.

Lake name	# of inlets	depth/width (m)	Length (m)	Dominant substrate	Barrier type/ distance from outlet (m)	% Spawning substrate
Fly	Seeps	NA	NA	NA	NA	NA
Heather	2	0.4 / 2	100	Silt / sand / gravel	waterfall /100	25
Platinum	Seeps	NA	NA	NA	NA	NA
Running	1	0.3/ 1	20	Silt/gravel	waterfall / 20	45

Table 7. Outlet characteristics of lakes stocked with tiger muskellunge in 2006 in the Clearwater Region.

Lake name	Number of outlets	Depth/width (m)	Length (m)	Dominant substrate	Barrier type/ distance from outlet (m)	% Spawning substrate
Fly	1	0.075 / 0.50	10	Boulders /rubble	High Gradient / 10	0
Heather	1	0.05 / 0.20	40	Silt	Seasonally dry	0
Platinum	1	0.05 / 0.50	150	Rubble / silt	none	0
Running	1	0.10 / 5	25	Silt / gravel / LWD	none	20

LWD=large woody debris

Table 8. Physical characteristics of lakes in the Clearwater Region stocked with tiger muskellunge on June 29, 2006 and the brook trout population estimate prior to tiger muskellunge introductions.

Lake name	Lake size (ha)	Max. lake depth (mm)	Total # of TM Stocked (density)	2006 BKT population est.
Fly	1.02	3.3	41(40 fish/ha)	299 (293 fish/ha)
Heather	2.62	9.0	106 (40 fish/ha)	N/A
Platinum	1.00	4.1	40 (40 fish/ha)	148 (148 fish/ha)
Running	8.40	14	349 (40 fish/ha)	3,389 (403 fish/ha)

TM=Tiger Muskellunge, BKT=Brook trout

Table 9. Population estimates (N), using an Adjusted Petersen Estimate, of brook trout in five high mountain lakes in the Clearwater Region prior to tiger muskellunge introductions in 2006.

					90% CI		
Lake name	**M**	**C**	**R**	**N**	**UL**	**LL**	**Fish/ha**
Fly	68	64	14	299	407	191	293
Heather	19	8	0	N/A	N/A	N/A	N/A
Platinum	7	36	1	148	285	11	148
Running	390	77	8	3,389	5,047	1,658	403

Table 10. Comparisons of brook trout catch rates and lengths in high mountain lakes in the Clearwater Region gill netted pre (2004 and 2006) and post (2007, 2008, and 2006) tiger muskellunge introduction.

Lake name	**CPUE (fish/hr)**	**Minimum length (mm)**	**Maximum length (mm)**	**Mean length (mm)**	**Standard deviation**
Fly 2006	5.33	109	274	231	40.12
Fly 2007	1.33	255	297	274	12.30
Fly 2008	0.58	253	304	286	16.27
Fly 2009	0	n/a	n/a	n/a	n/a
Heather 2004	0.64	142	353	309	69.52
Heather 2007	1.00	218	374	322	42.50
Heather 2008	0.72	317	366	344	14.28
Heather 2009	0.18	325	342	337	8.34
Platinum 2006	3.00	128	330	220	50.12
Platinum 2007	0.79	241	332	294	28.28
Platinum 2008	1.03	114	353	203	95.20
Platinum 2009	0.60	128	377	231	71.74
Running 2006	5.31	100	225	181	21.44
Running 2007	3.87	102	220	190	18.71
Running 2008	3.39	91	264	191	42.11
Running 2009	6.33	105	295	162	39.81

Table 11. Summary of weights from brook trout captured in high mountain lakes in the Clearwater Region gill netted pre (2004 and 2006) and post (2007 and 2008) tiger muskellunge introduction.

Lake name	**Min. weight (g)**	**Max. weight (g)**	**Mean weight (g)**	**Relative weight (W_r)**	**Standard deviation**
Fly 2006	15	190	117	88	41.03
Fly 2007	143	255	212	98	28.45
Fly 2008	205	360	290	124	49.89
Fly 2009	n/a	n/a	n/a	n/a	n/a
Heather 2004	*	*	*	*	*
Heather 2007	100	515	320	88	105.89
Heather 2008	170	470	391	91	82.36
Heather 2009	300	380	350	86	34.64
Platinum 2006	20	385	115	93	76.69
Platinum 2007	155	395	288	105	75.44
Platinum 2008	15	500	159	96	180.00
Platinum 2009	25	580	155	98	160.26
Running 2006	*	*	*	*	*
Running 2007	*	*	*	*	*
Running 2008	10	220	78	98	39.17
Running 2009	10	220	46	92	33.95

* = Field crews did not record weights of brook trout during these years

Table 12. Pairwise comparisons of mean brook trout lengths between years pre (2004, 2006) and post (2007, 2008, and 2009) tiger muskellunge introductions using Tukey's multiple range comparison test. A p–value of 0.05 was used to denote significant differences.

Lake	**Year**	**Mean length est.**	**Standard deviation**	**Pairwise grouping**
Fly	2006	231	40.12	A
	2007	274	12.30	B
	2008	286	16.27	B
	2009	n/a	n/a	n/a
Heather	2004	309	69.52	A
	2007	322	42.50	A
	2008	344	14.28	A
	2009	337	8.34	A
Platinum	2006	220	50.12	A
	2007	294	28.28	B
	2008	203	95.2	A
	2009	231	71.74	AB
Running	2006	181	21.44	A
	2007	190	18.71	AB
	2008	191	42.11	B
	2009	162	39.81	C

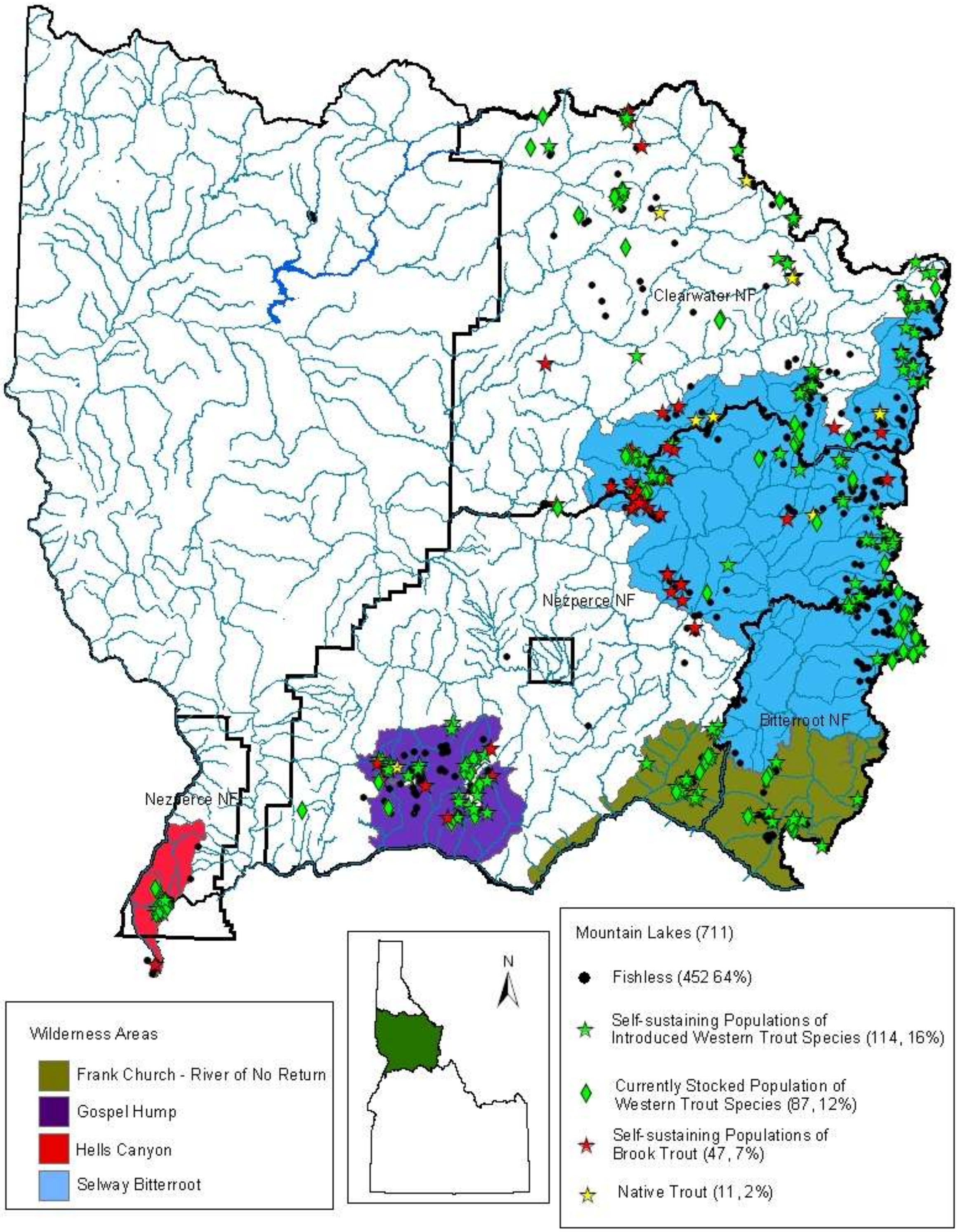

Figure 8. Distribution and fish related status of mountain lakes in the IDFG Clearwater Region.

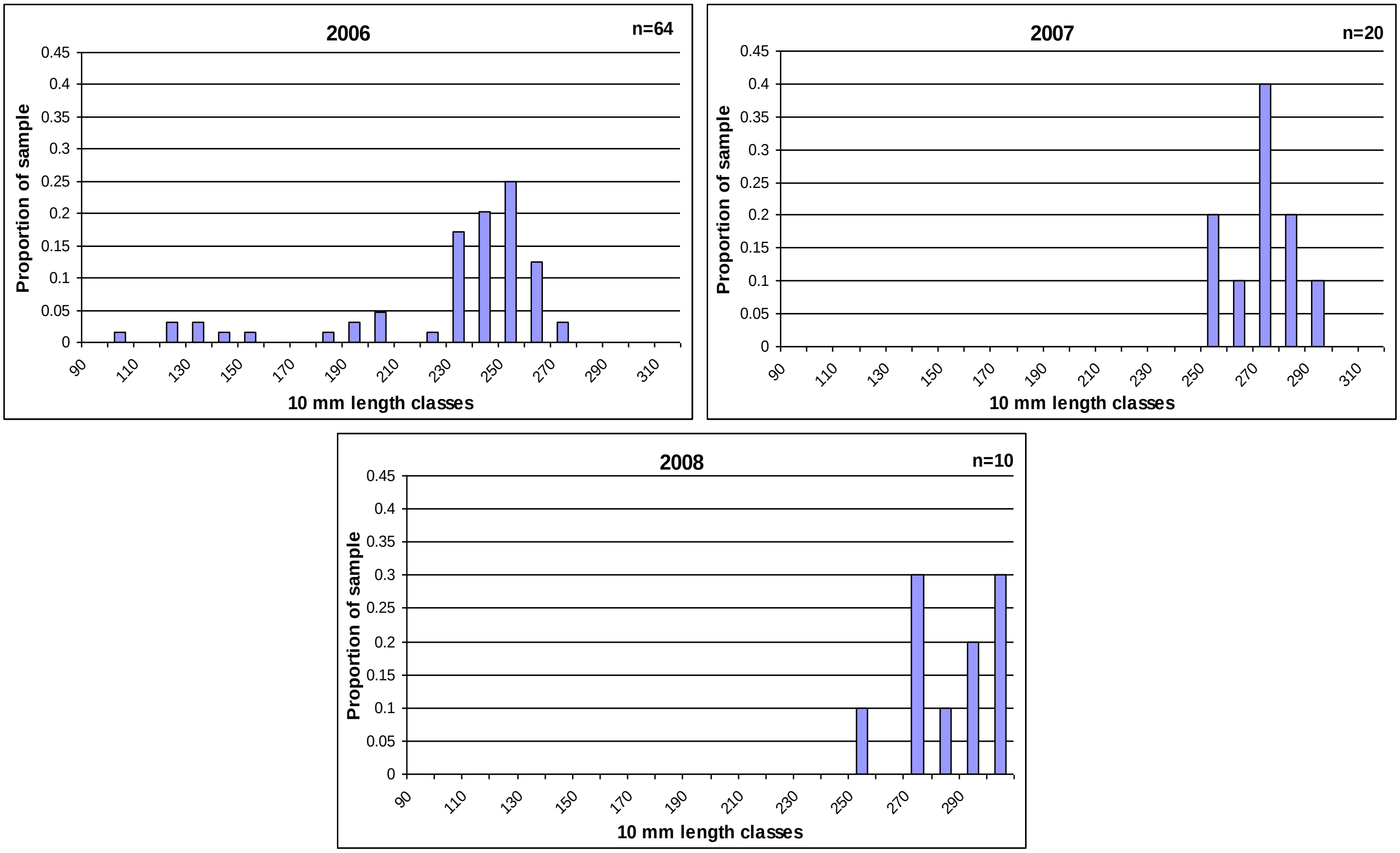

Figure 9. Length frequency histograms of brook trout captured by gill netting in Fly Lake in the Clearwater Region, pre (2006) and post (2007 and 2008) tiger muskellunge introductions. No brook trout were captured from Fly Lake in 2009 gill netting efforts.

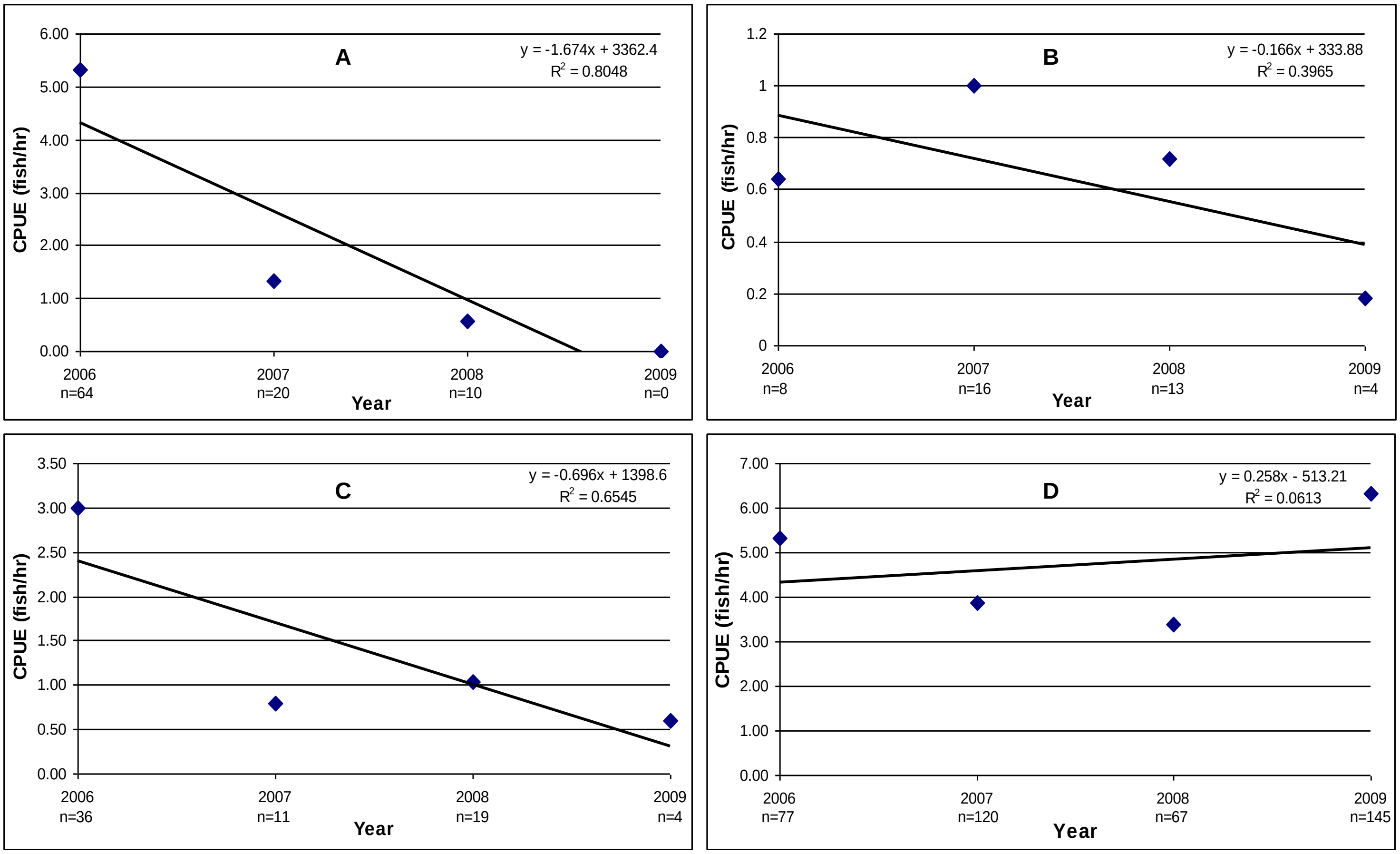

Figure 10. Linear regression of brook trout CPUE from pre (2006) and post (2007, 2008, 2009) tiger muskellunge introductions in the Clearwater Region; (A) Fly Lake, (B) Heather Lake, (C) Platinum Lake, (D) Running Lake.

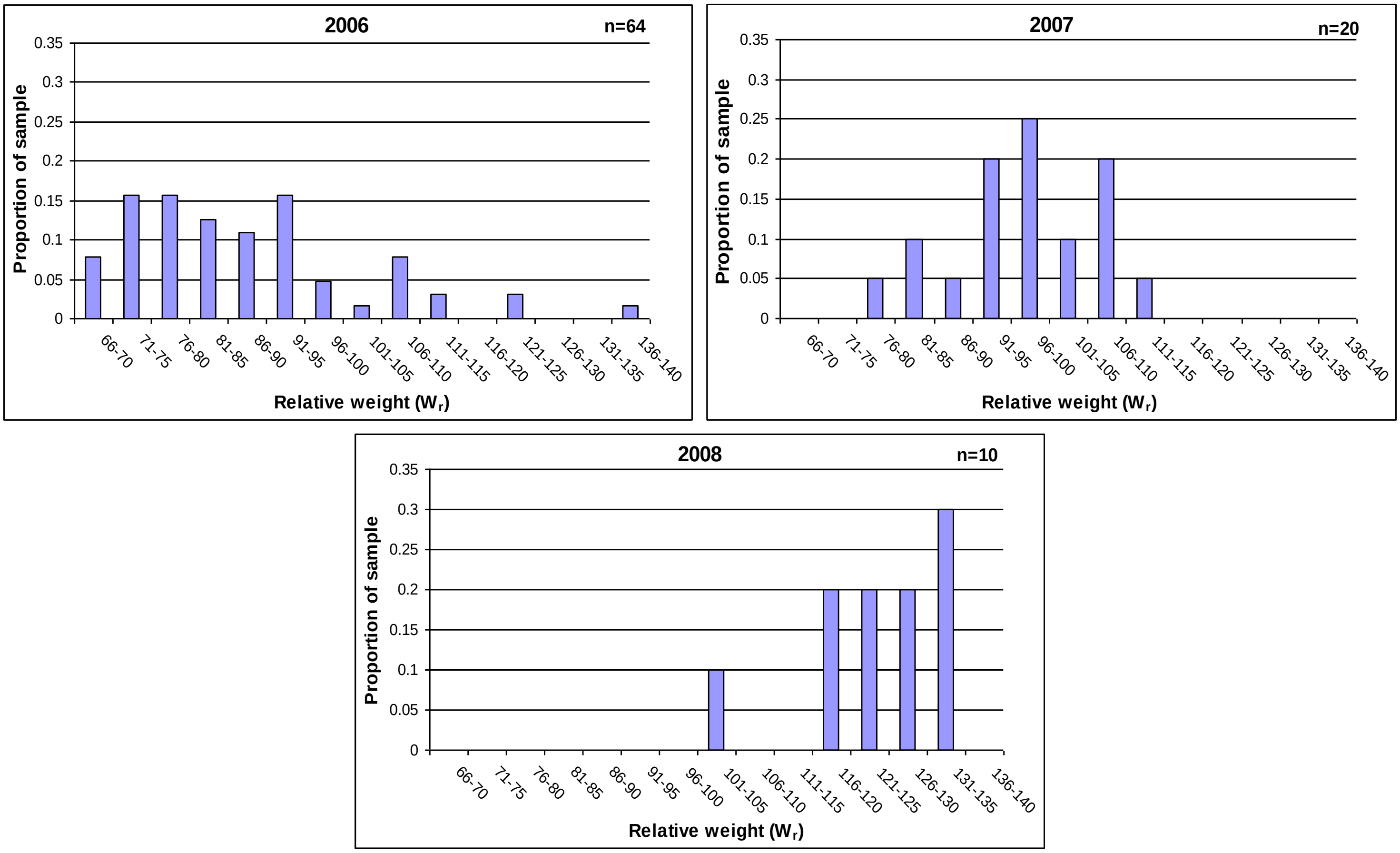

Figure 11. Relative weight (W_r) histograms of brook trout captured by gill netting in Fly Lake in the Clearwater Region, pre (2006) and post (2007, 2008, and 2009) tiger muskellunge introductions. No brook trout were captured from Fly Lake in 2009 gill netting efforts.

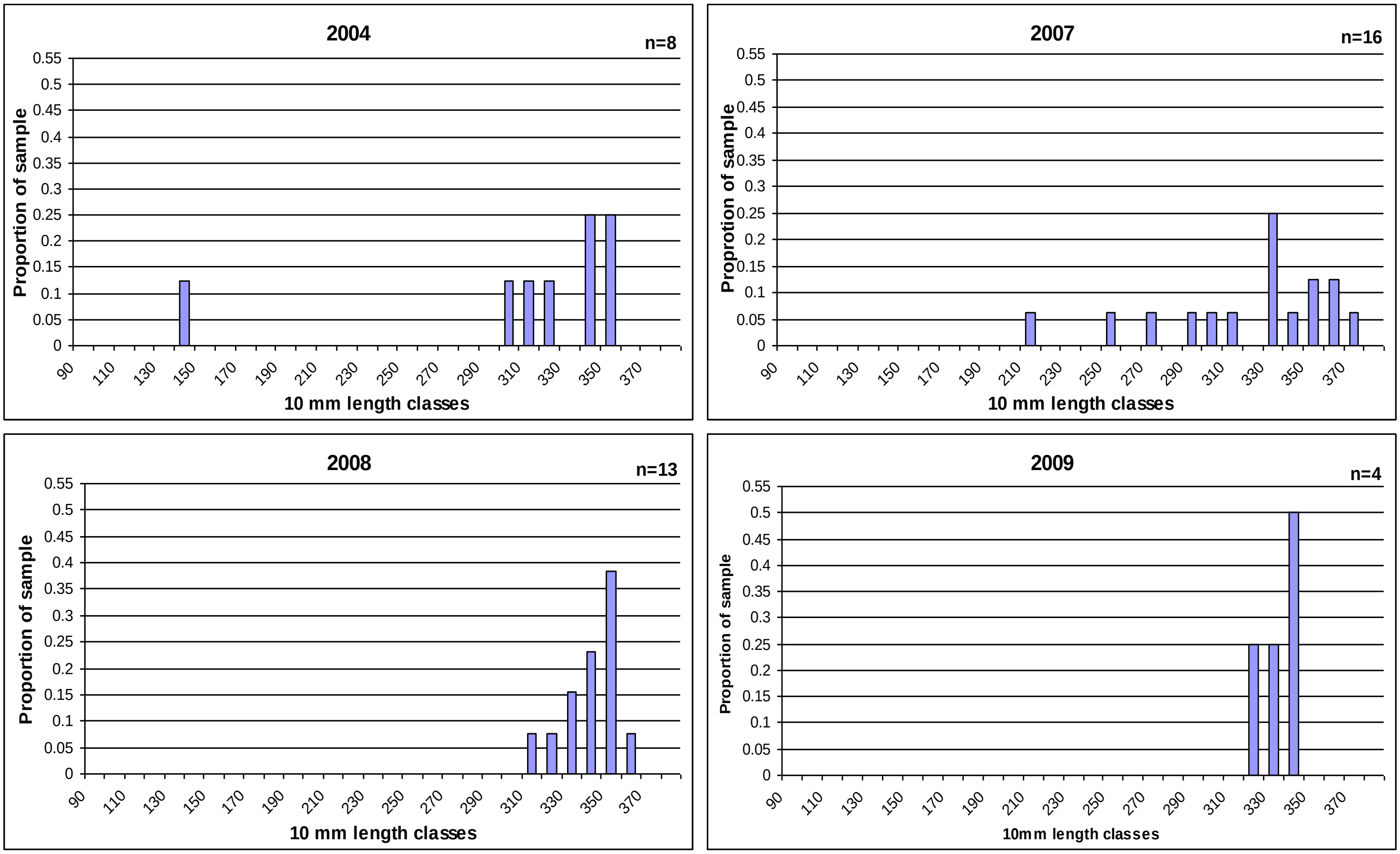

Figure 12. Length frequency histograms of brook trout captured by gill netting in Heather Lake in the Clearwater Region, pre (2004) and post (2007, 2008, and 2009) tiger muskellunge introductions.

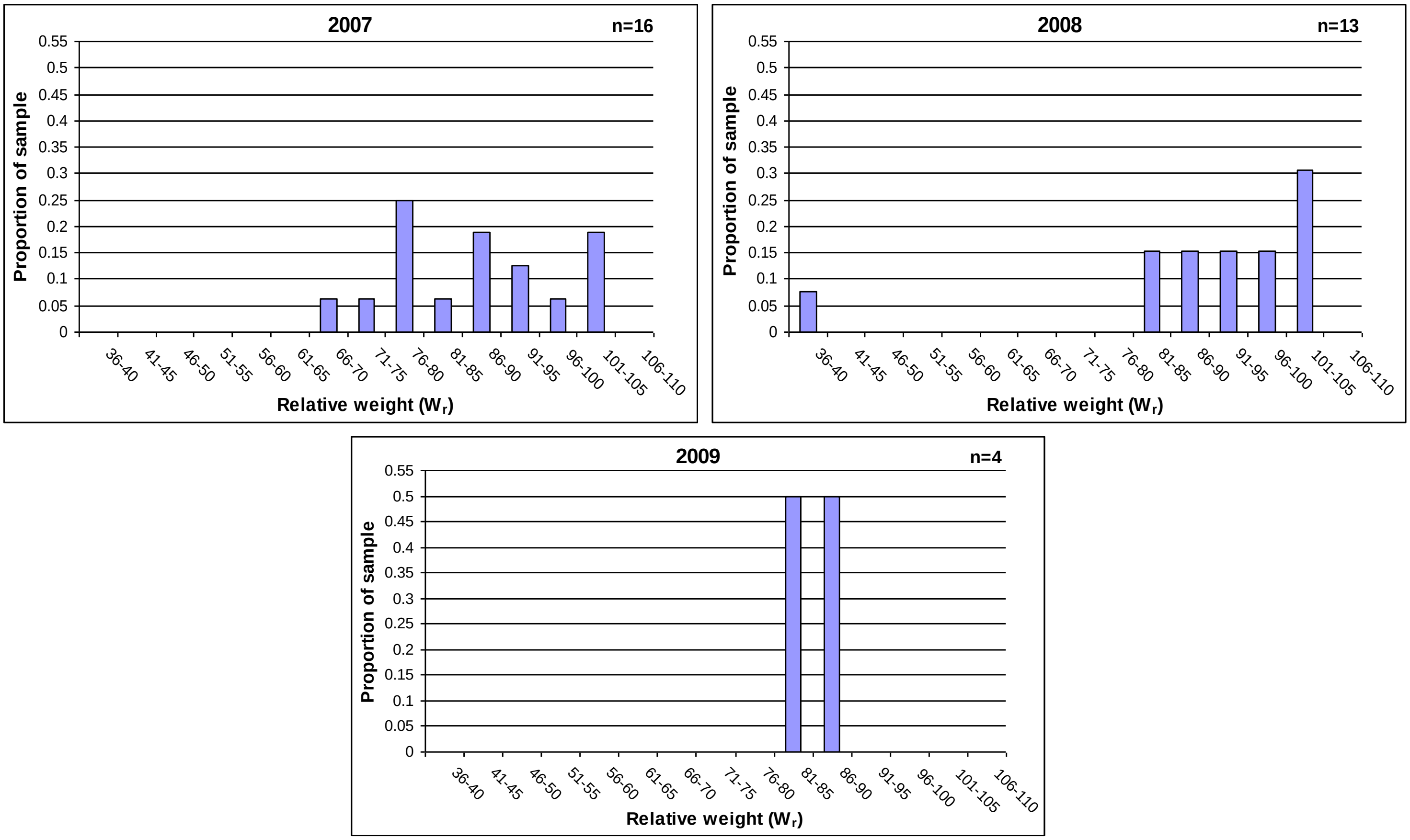

Figure 13. Relative weight (W_r) histograms of brook trout captured by gill netting in Heather Lake in the Clearwater Region, post (2007, 2008, and 2009) tiger muskellunge introductions.

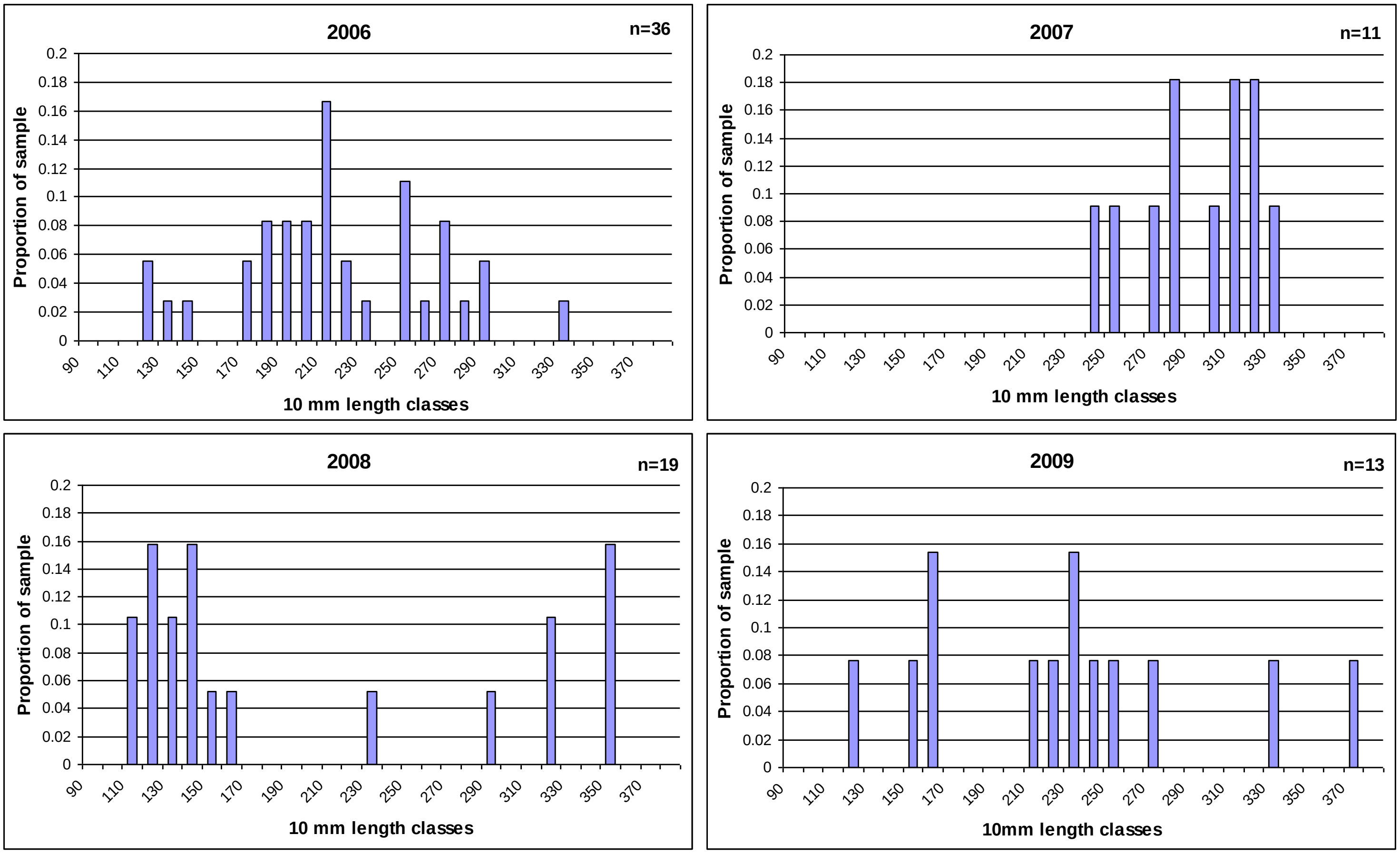

Figure 14. Length frequency histograms of brook trout captured by gill netting in Platinum Lake in the Clearwater Region, pre (2006) and post (2007, 2008, and 2009) tiger muskellunge introductions.

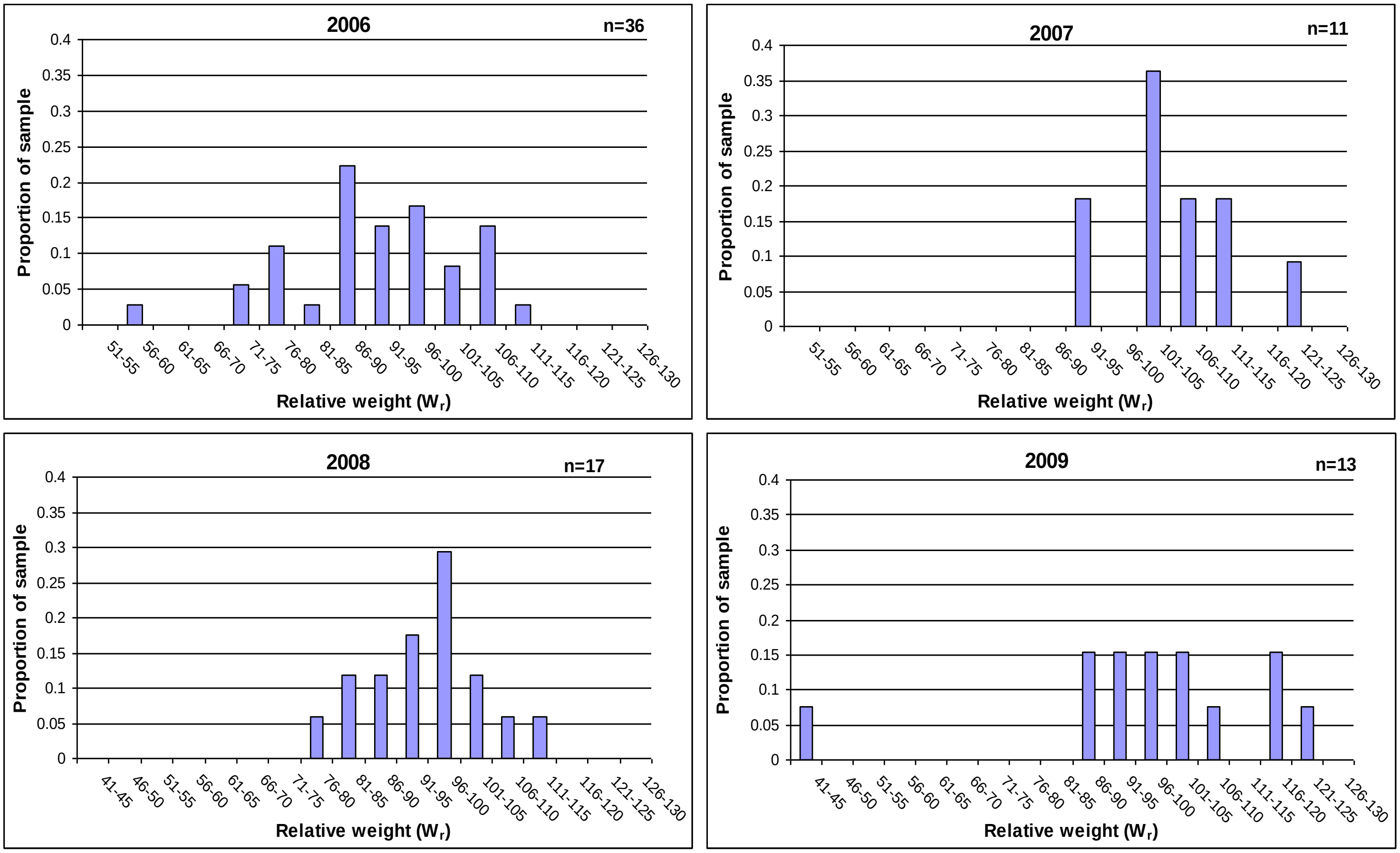

Figure 15. Relative weight (W_r) histograms of brook trout captured by gill netting in Platinum Lake in the Clearwater Region, pre (2006) and post (2007, 2008, and 2009) tiger muskellunge introductions.

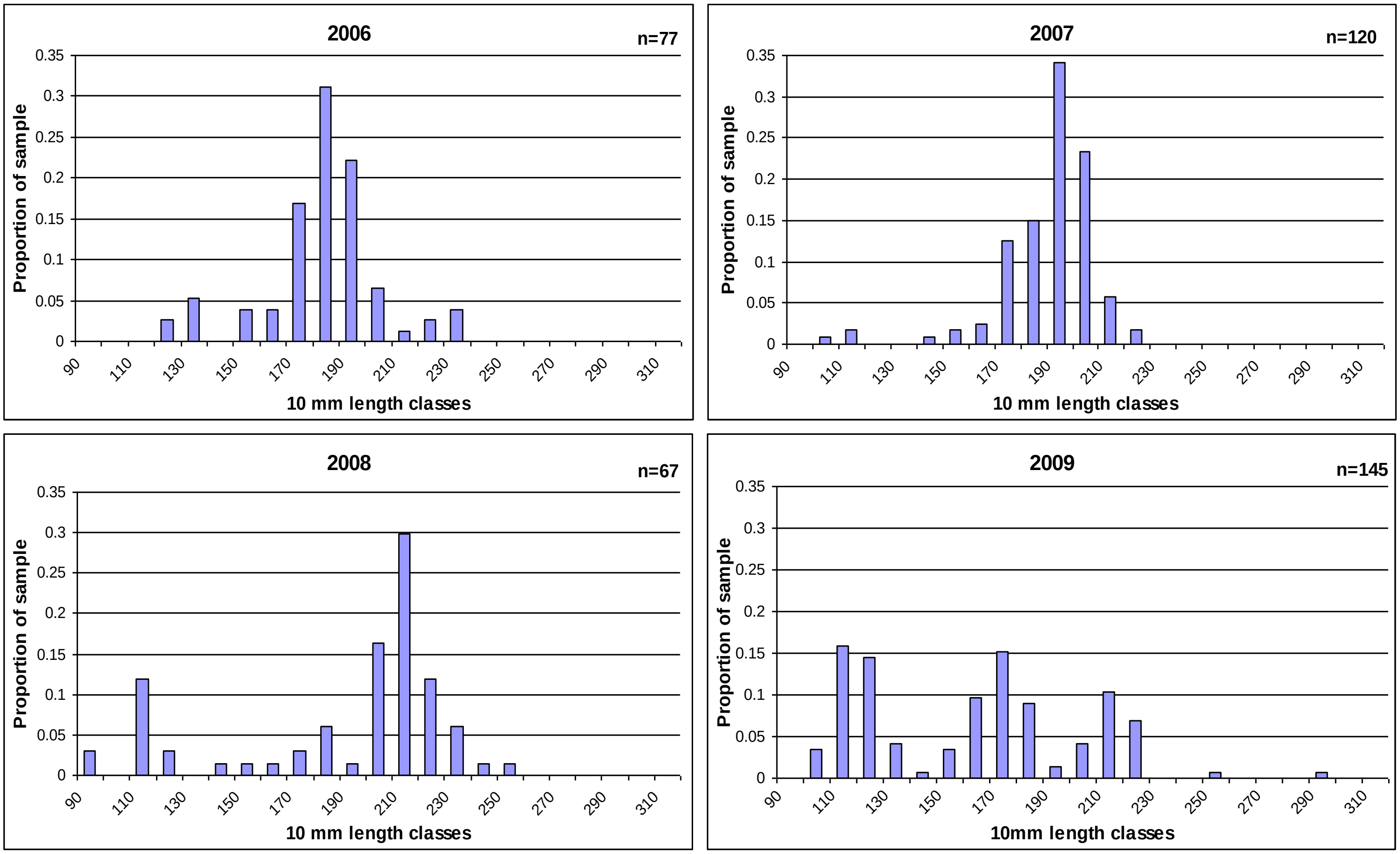

Figure 16. Length frequency histograms of brook trout captured by gill netting in Running Lake in the Clearwater Region, pre (2006) and post (2007, 2008, and 2009) tiger muskellunge introductions.

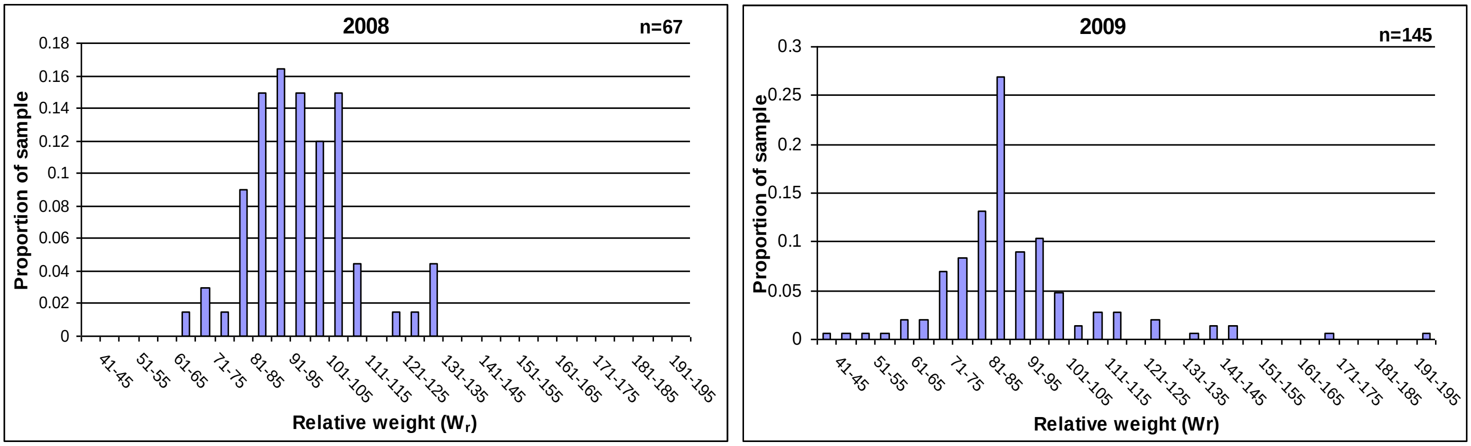

Figure 17. Relative weight (W_r) histogram of brook trout captured by gill netting in Running Lake in the Clearwater Region, post (2008 and 2009) tiger muskellunge introductions.

Figure 18. Pictures of brook trout captured in overnight gill net sets in the Clearwater Region, 2009 in (A) Heather Lake, (B) Platinum Lake, and (C) Running Lake. No brook trout were captured from Fly Lake in 2009.

LAKES AND RESERVOIRS INVESTIGATION

Habitat Management

ABSTRACT

Herbicide applications were conducted on several ponds in the Clearwater Region to control nuisance aquatic vegetation. A total of 4.5 L of the aquatic herbicide Reward® was applied during 2009 to the Burling Pond, Fred Warren Pond, and Robinson Pond. These applications are highly effective, reducing vegetation coverage to less than 5% after each treatment. Subsequent regrowth was limited to 20 - 25% coverage by the end of the summer. Applications should continue to be used as needed to control nuisance aquatic vegetation in regional ponds. However, due to the limited success of small scale herbicide treatments in larger reservoirs, other techniques for controlling nuisance aquatic vegetation such as large scale herbicide treatments, aquatic weed barriers, grass carp, and winter drawdown will be evaluated beginning in 2013.

A bathymetric map was developed for Winchester Lake, and the lake was determined to be 44.4 ha in surface area. It has a maximum depth of 11.6 m and a volume of 185 ha-m at full pool. Maps for Elk Creek Reservoir and Moose Creek Reservoir could not be completed due to heavy aquatic macrophyte growth, which caused inaccurate depth readings. The data collection for these maps will be completed when conditions allow.

Limnology sampling, consisting of temperature and dissolved oxygen profiles, were taken monthly on regional reservoirs to provide information for management decisions. At their lowest percent of total reservoir volume available for trout to survive, Deer Creek Reservoir was reduced to 25.5%, Mann Lake to 7.7%, Soldier's Meadow Reservoir to 42.2%, Spring Valley Reservoir to 27.2%, Tolo Lake to 37.0%, and Winchester Lake to 0.0%. Fall stockings of catchable trout should only be conducted in Winchester Lake after fall turnover to avoid fish kills. Additionally, using this data we recommend transitioning from a catchable trout program to a put-grow-and take trout fishery in Deer Creek Reservoir, Soldier's Meadow Reservoir, and Waha Lake.

Dissolved oxygen levels were monitored in the hypolimnetic aeration system in Winchester Lake. As in previous years, an increase of 1 - 2 mg/L of oxygen was recorded within the system. However, during summer months, the biological oxygen demand (BOD) of the reservoir uses up much of this oxygen. The result is minimal amounts of oxygen actually added to the water returning into the reservoir. The aeration system in Waha Lake was inoperable due to ice damage. Low water in 2009 again prevented repairs from being made. Due to these issues, the aeration system in Waha Lake should be removed.

Author:

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INTRODUCTION

Several projects were carried out in the Clearwater Region of Idaho to provide better fishing opportunities for the public, and to collect information that will improve the management of those fisheries. These included habitat manipulation and monitoring to improve environmental conditions for fish or improve conditions to allow for more fishing opportunity.

IDFG has written a management plan to guide current and future management for nine lowland lakes in the Clearwater Region. A primary goal of this management plan is the improvement of water quality and aquatic habitat within the reservoirs. As part of this water quality and habitat improvement, IDFG proposes to address water quality issues in the Burling Pond, Robinson Pond, Spring Valley Reservoir, and Winchester Lake. Specifically, we are targeting the excessive algae and aquatic macrophyte growth that occurs in these reservoirs beginning each spring and continuing though the fall. The reservoirs are highly eutrophic and are becoming more so as additional nutrients enter the system. Increased levels of aquatic vegetation lead to increases in anoxic conditions when these plants die and decay. The aquatic herbicide Reward® was applied in the spring to suppress growth of these plants, resulting in a substantial reduction in nuisance aquatic vegetation growth. This will enhance recreational fishing and boating, which are important recreational activities on these reservoirs.

The primary beneficial uses affected by this project are the recreational and economic importance of these reservoirs. The popularity of these reservoirs is directly related to the quality of sport fishing and water quality. The recreational fisheries alone from these four reservoirs annually account for over 112,000 hours of fishing effort and generate an annual estimated economic value of over $2.9 million. Failure to act toward improving water quality and access jeopardizes this recreational and economic benefit. One way to address the excess vegetation growth is through the use of aquatic herbicides. Herbicides have been widely used to reduce nuisance aquatic plant growth in lakes and ponds in the United States to improve their aesthetics, access, and habitat quality.

Dissolved oxygen (DO) and temperature profiles were conducted monthly on regional lowland lakes and reservoirs. This information was collected to provide long-term information on each reservoir, and to calculate the volume of each reservoir available for hatchery trout on a monthly basis.

Developing bathymetric maps will provide managers with a better understanding of the shape, volume, and mean and average depth of the reservoirs. Currently, we have only basic, hand drawn bathymetric maps which are not very accurate. Highly detailed maps would provide much better information for managers and anglers. This includes calculating the volume of water available for trout to live in on a monthly basis, and knowing the surface area and total volume of the reservoirs for projects such as macrophyte control or fish removal.

To address the poor water quality that has become a significant problem in Winchester Lake, a hypolimnetic aeration system was installed in 2001 - 2002. During 2009, DO and water temperature continued to be monitored to determine the effectiveness of the aeration system.

OBJECTIVES

1. Control nuisance aquatic vegetation in regional reservoirs and ponds to improve fisheries and recreation access.

2. Develop bathymetric maps for all regional lowland lakes and reservoirs to provide detailed depth and volume measurements for future management projects.

3. Complete the installation of a pipe to provide water from Quinlan Spring to Robinson Pond to improve the fishery.

4. Monitor dissolved oxygen and temperature profiles in all regional lowland lakes to provide historical limnology data for current and future management planning.

5. Utilize hypolimnetic aeration systems in Winchester Lake and Waha Lake to increase dissolved oxygen levels and reduce phosphorous loading in the hypolimnion.

STUDY AREAS

Descriptions of regional lowland reservoirs and ponds can be found in Hand et al. (2011). A map of the study area is located in Figure 19.

METHODS

The volumes of reservoirs available for rainbow trout to survive were calculated using a minimum DO concentration and a temperature of at which rainbow trout become stressed. A minimum DO concentration of 5.0 mg/L was selected, as this is considered a point at which rainbow trout growth, food conversion, and swimming performance rates become limited (Davis 1975, Bjornn and Reiser 1991). This DO concentration is also the standard set for IDFG standard lake surveys by Horton (1992). An upper thermal limit of 21.0˚C was selected, as this was the temperature set for IDFG standard lake surveys by Horton (1992), as well. This is below the 23.0˚C Bjornn and Reiser (1991) determined to be the temperature at which rainbow trout begin experiencing high stress levels and actively seek cooler temperatures. The volume of reservoir available for rainbow trout was then calculated by totaling the volume of water in each reservoir between these temperature ranges and oxygen limits.

Methodology for herbicide applications, development of bathymetric maps, DO and temperature profiles, and hypolimnetic aeration system monitoring can be found in Hand et al. (2011). Reservoir volumes were calculated in acre-ft, as this is a standard volume measurement and is necessary for management activities such as pesticide and rotenone applications, and water drawdowns.

RESULTS

Aquatic Vegetation Control

Burling Pond and Fred Warren Pond

The aquatic herbicide Reward® was applied on April 27^{th}, 2009 to control nuisance aquatic vegetation that greatly reduces fishing opportunity in these two ponds (Table 13). The vegetation is a combination of Elodea *Elodea canadensis* and filamentous algae. Within two weeks of the herbicide application, surface coverage of the vegetation was reduced from approximately 50% in the Burling Pond and 75% in the Fred Warren Pond to less than 5% coverage in each pond. As in 2008, vegetation regrew to approximately 20% - 25% coverage after two months. No follow-up applications were made in 2009.

Robinson Pond

The aquatic herbicide Reward® was applied on April 29^{th} to control nuisance aquatic vegetation that greatly reduces fishing opportunity in this popular fishing pond near Kamiah, Idaho (Table 13). The vegetation in Robinson Pond is a combination of Elodea and filamentous algae. Surface coverage was reduced from approximately 40% to less than 5% within a period of two weeks. A second application was made on June 26^{th} to maintain control. At this time vegetation had re-grown to a surface coverage of approximately 10 - 15%. Again, post application coverage was less than 5%.

Bathymetric Map Development

A bathymetric map was developed for Winchester Lake, and the lake was determined to be 44.4 ha in surface area (Figure 20). It has a maximum depth of 11.6 m and a volume of 1,501.0 acre-ft or 185 ha-m at full pool (Appendix M).

Bathymetric maps for Elk Creek Reservoir and Moose Creek Reservoir could not be completed due to heavy aquatic macrophyte growth. This growth caused inaccurate depth readings. The data collection for these maps will be completed as soon as conditions allow.

Robinson Pond Pipe Installation

Due to the decline of habitat quality in Robinson Pond (aquatic vegetation, low water), we were unable to stock hatchery rainbow trout in the pond as scheduled during 2006 - 2008. This prompted IDFG, in cooperation with the Upper Clearwater Community Foundation (UCCF) and Flying B Ranch in Kamiah, Idaho to improve habitat quality in the pond and recreational access. Water for the pond is supplied from Quinlan Spring, a natural spring approximately one km upstream of the pond along Lawyers Creek. A new permanent sewer grade pipe was installed during 2009. This resulted in the maximum amount of water possible reaching the pond, providing an improved fishery and recreational experience. Additional work to the site (provided by the UCCF) included a large sign/educational kiosk, picnic table and portable restroom facilities. Monthly DO and temperature profiles were conducted beginning in September (Table 14).

Dissolved Oxygen and Temperature Monitoring

Deer Creek Reservoir

Monthly dissolved oxygen (DO) and temperature profiles are shown in Table 14. Data was collected from May - November, 2009. The metalimnion occurred below a depth of 3 m during the entire sampling period, as DO levels dropped from over 4.5 mg/L to under 2.4 mg/L at this depth. Water temperature reached a high on the surface of 23.4˚C in July. This was the only incidence of temperatures over 23.0˚C recorded during the year.

Due to these conditions, the livable volume for rainbow trout in the reservoir becomes reduced (Table 15). Utilizing the minimum DO level of 5.0 mg/L (Davis 1975, Bjornn and Reiser 1991) and an upper thermal limit of 21.0˚C (Horton 1992), the volume of the reservoir available for rainbow trout was reduced to 371.6 acre-ft (48.9% of total volume) or 45 ha-m in July, 193.5 acre-ft (25.5%) or 24 ha-m in August, and 450.0 acre-ft (59.2%) or 55.5 ha-m in September.

Elk Creek Reservoir

Monthly DO and temperature profiles are shown in Table 2. During the summer months, the metalimnion occurred at a depth of 4 m in August and September. At the metalimnion, DO levels dropped from over 7.0 mg/L to below 3.0 mg/L. However, as Elk Creek Reservoir has a maximum depth of approximately 6 m, DO levels stayed above 5.0 mg/L through the majority of the water column during most of the summer. During 2009, water temperature reached a high on the surface of 22.9˚C in August.

Mann Lake

Monthly DO and temperature profiles are shown in Table 14. During July - October, the metalimnion occurred at a depth of 9 m or more, where DO dropped to under 3.0 mg/L. Water temperatures reached a high on the surface of 25.3˚C in August. In July, temperatures were above 23.0˚C down to a depth of 3 m. Due to these conditions, the livable volume for rainbow trout in the reservoir becomes greatly to 558.2 acre-ft (32.0% of total volume) or 69 ha-m in July, 133.8 acre-ft (7.7%) or 16.5 ha-m in August, and 256.1 acre-ft (14.7%) or 31.5 ha-m in September (Table 15).

Moose Creek Reservoir

Monthly DO and temperature profiles are shown in Table 14. During August, the metalimnion occurred at a depth of 3 m, where DO dropped from 6.4 mg/L to 1.7 mg/L. In June, July, and September, the metalimnion was at a depth of 4 m, with DO concentrations above 5.0 mg/L down to the metalimnion. Water temperatures reached a high of 22.5˚C on the surface in August. No livable volumes were calculated, as a bathymetric map has not been developed for Moose Creek Reservoir.

Soldier's Meadow Reservoir

Monthly DO and temperature profiles are shown in Table 14. During July - September, the metalimnion occurred at a depth of 5 m, where DO dropped from over 4.0 mg/L to <1.0 mg/L. In other months, there was no distinct stratification. Water temperature reached a maximum of 21.7˚C in August. Due to these conditions, the livable volume for rainbow trout in the reservoir was reduced to 656.6 acre-ft (67.8% of total volume) or 81 ha-m in August, and 794.9 acre-ft (51.1%) or 98 ha-m in September (Table 15).

Spring Valley Reservoir

Monthly dissolved oxygen profiles are shown in Table 14. During June, July, and September, the metalimnion occurred at a depth of 4 m, where DO dropped from over 6.7 mg/L to <2.0 mg/L. In August, the metalimnion occurred at a depth of 3 m, with DO concentrations dropping from 12.5 mg/L to 5.7 mg/L. Water temperature reached a high of 23.0˚C on the surface in August. Due to these conditions, the livable volume for rainbow trout was reduced to 276.8 acre-ft (37.6% of total volume) or 34.1 ha-m in July, and 199.9 acre-ft (27.2%) or 24.7 ha-m in September (Table 15).

Tolo Lake

Monthly dissolved oxygen profiles are shown in Table 14. During June and August, the metalimnion occurred at a depth of 2 m, where DO dropped from at least 4.8 mg/L to <0.5 mg/L. In other months, no stratification was present. Water temperature reached a high of 22.4˚C on the surface in August.

Due to these conditions, the livable volume for rainbow trout in the reservoir was reduced to 0.0 acre-ft in August, 114.8 acre-ft (46.4% of total volume) or 14 ha-m in June, and 132.6 acre-ft (53.6%) or 16.3 ha-m in July.

Waha Lake

Monthly dissolved oxygen profiles are shown in Table 14. During May - June, there was no discernable metalimnion down to a depth of 12 m, where sampling was ended. In August and September, the metalimnion occurred at a depth of 4 m, where DO concentrations dropped from over 10.3 mg/L to <8.1 mg/L. DO concentrations remained above 5.0 mg/L down to a depth of at least 12 m during the entire sampling period. The maximum water temperature was 22.0˚C in August. Reductions in livable volume for rainbow trout were not calculated, as DO and temperature readings were only recorded to a depth of 12 m (maximum length of probe cable).

Winchester Lake

Monthly dissolved oxygen profiles are shown in Table 14. DO levels remained above 5.0 mg/L throughout the water column in May and November. During June - September, the metalimnion occurred at a depth of 3 m, where DO dropped from >5.1 mg/L to <1.0 mg/L. This resulted in a reduction in the livable volume for trout in the reservoir to 748.7 acre-ft (49.9% of total volume) or 92.3 ha-m during those months. In October, fall turnover caused the entire water volume to have a DO of < 5.0 mg/L. Thus, the entire water body had oxygen levels below the level at which trout become stressed (Davis 1975; Bjornn and Reiser 1991). The water temperature reached a maximum of 21.7˚C in August.

Hypolimnetic Aeration

During 2009, the hypolimnetic aeration system in Winchester Lake was in full operation. DO levels within the aeration units were increased between 0.2 - 1.2 mg/L (Table 16). The hypolimnetic aeration system in Waha Lake was inoperable during 2009 due to ice damage from the previous winter. Maintenance on the aeration system again could not be conducted due to extremely low water which prevented larger boats from being launched on the lake.

DISCUSSION

Aquatic Vegetation Control

The results indicate that herbicide treatments are highly successful in small ponds. Surface coverage was reduced to less than 5% after each application, with a single subsequent treatment (made approximately two months later) sufficient to maintain control. The result was substantially improved angler access to these ponds. These treatments should be continued to effectively control vegetation in regional ponds.

Due to the limited success of small scale herbicide treatments in regional reservoirs, other techniques for controlling nuisance aquatic vegetation, including biological, mechanical, physical, and chemical control were researched. Based on the advantages and disadvantages of each, grass carp *Ctenopharyngodon idella*, benthic barriers, and winter drawdown appear to be the best potential candidates for use in regional reservoirs (Hand et al. 2011).

Vegetation control experiments should be conducted on Spring Valley Reservoir, Winchester Lake, Moose Creek Reservoir, and Robinson Pond. We recommend testing winter drawdown in Spring Valley Reservoir and Moose Creek Reservoir, benthic barriers in Winchester Lake, and grass carp in Robinson Pond. Beginning in spring 2012, limnological and fisheries data will be collected in each water body to provide pre-treatment data. This will consist of monthly DO and temperature profiles and standard fish surveys. Aquatic vegetation will be measured for percent coverage, and for weight of vegetation per square meter. This will allow for comparisons of before and after treatments.

With this sampling schedule, treatments could begin in the fall of 2012 or in 2013. Effectiveness of the treatments will be monitored for several years post treatment, and should consist of limnology sampling, standard fish surveys, and quantification of vegetation coverage and weight per square meter.

Bathymetric Map Development

A bathymetric map was successfully developed for Winchester Lake. This highly detailed map and the accompanying volume calculations will provide useful information for future management decisions such as reservoir drawdowns, rotenone applications, and vegetation control using herbicides. Development of these maps for Moose Creek Reservoir and Elk Creek Reservoir should be completed as soon as conditions permit.

Robinson Pond Pipe Installation

The completion of the inflow pipe installation has resulted in a greatly improved pond in terms of water quality, fish habitat, and recreational fishing opportunities. Water levels in the pond are now stabilized at full pool. Water temperatures and quality are providing an excellent fishery, and as a result, hatchery rainbow trout stockings have been increased from 4,000 fish stocked in the spring to 7,750 fish stocked in the spring and fall. While effort has not been estimated using a creel survey, reports from anglers indicate that there has been an increase in effort and that the majority of these fish are caught within two weeks of being stocked.

Dissolved Oxygen and Temperature Monitoring

The combination of an anoxic hypolimnion and warm surface waters greatly reduces the volume of the reservoir available for fish to live during the summer months, especially temperature sensitive hatchery trout (Table 15). These conditions force the more temperature sensitive trout to live in either the warmer epilimnion with higher DO, or cooler water with less DO, both of which can cause stress. The combination of high water temperature and marginal DO concentrations compounds the stress on hatchery trout, which can result in disease and fish kills (Bjornn and Reiser 1991, Carline and Machung 2001).

The causes of low DO levels are due to the high level of organic material in the reservoirs. This material consumes oxygen as it decomposes, thus reducing the oxygen levels in the hypolimnion. As seen in previous years, Mann Lake does not experience the extreme stratification and loss of DO in the hypolimnion that is seen in other regional reservoirs. This is probably due to its relatively low organic load, and higher transfer of oxygen from wind and wave action (the reservoir is in open farmland as opposed to other reservoirs which are surrounded by trees). However, due to its lower elevation, Mann Lake becomes warmer than other reservoirs, which can cause stress (and sometimes fish kills) to stocked trout. Also as seen previously, Waha Lake also does not experience the extreme stratification and limited water volume available for trout. This is likely due to its lower organic load and greater volume and depth. As we have seen in previous years, Winchester Lake continues to have severe anoxic conditions in the hypolimnion, and this resulted in the reservoir volume available for trout being reduced to 0.0% in October during fall turnover. This is a concern for our fall stocking of catchable trout in this reservoir. To avoid potential fish kills, fall stockings should be conducted once DO levels have returned to above 5.0 mg/L after fall turnover.

Based on DO and temperature data, Deer Creek Reservoir, Soldier's Meadow Reservoir, and Waha Lake would be suitable for utilizing put-grow-take rainbow trout fisheries. Even though livable volume was reduced to 25.5% during August in Deer Creek Reservoir, it was included in the recommendation since overwinter survival has contributed to an excellent fishery since the reservoir was built. We recommend a gradual shift from catchable rainbow trout stockings to put-grow-take over several years to allow the fingerlings to grow to catchable size. These fisheries would reduce the cost of the hatchery program and provide a more desirable product.

Based on limnology sampling over the past few years, monthly limnology sampling does not need to be conducted on all reservoirs. Monthly limnology sampling should be conducted in Tolo Lake throughout 2010, as we just started collecting this data monthly in 2009. For other reservoirs, limnology sampling should be conducted again in 2012 in conjunction with regional reservoir fish, creel, and habitat surveys.

Hypolimnetic Aeration

During 2009, the hypolimnetic aeration system in Winchester Lake showed only small increases in DO levels in the water exiting the system. This is similar to the results of the previous 7 years of operation, where DO levels only increased between 0.2 - 2.0 mg/L. A detailed discussion of the hypolimnetic aeration system can be found in Hand et al. (2011). Due to the apparent lack of improvement in DO levels in the hypolimnion, a project report should be written to fully analyze the available data and provide management recommendations regarding the future of this project and potential alternative management options.

In Waha Lake, oxygen levels over 5.0 mg/L continue to be recorded down to a depth of at least 12 m, providing sufficient habitat for trout. This, combined with the continued problems of winter ice damage, indicates there is no need to continue the operation of the hypolimnetic aeration system in this reservoir. Therefore, we recommend its removal from Waha Lake.

MANAGEMENT RECOMMENDATIONS

1. Develop a study on potential treatments for controlling nuisance aquatic vegetation in regional lowland lakes and reservoirs.
2. Utilize aquatic herbicides to control nuisance aquatic vegetation in small ponds. Conduct measurements of vegetation coverage pre- and post-treatment to provide a measure of effectiveness.
3. Complete the development of bathymetric maps for Elk Creek Reservoir and Moose Creek Reservoir.
4. Transition to put-grow-take trout fisheries in Deer Creek Reservoir.
5. Conduct fall stockings of catchable trout in Winchester Lake only after fall turnover and DO levels are above 5.0 mg/L to avoid potential fish kills.
6. In 2010, conduct monthly DO and temperature profiles on Tolo Lake to provide additional management data.
7. Include project summary report on Winchester Lake hypolimnetic aeration system to determine its effectiveness in 2012 annual report.
8. Remove hypolimnetic aeration system from Waha Lake.

Table 13. Historic record of herbicide applications in the Clearwater Region, Idaho.

Date	Location	Quantity (gal)	Product	Applicators
6/21/2006	Robinson Pond	0.50	Reward®	Hand
6/23/2006	Winchester Lake	4.00	Reward®	Hand
4/27/2007	Robinson Pond	1.00	Reward®	Hand, St. John
4/27/2007	Burling Pond	0.25	Reward®	Hand, St. John
5/9/2007	Elk Creek Reservoir	4.00	Reward®	Hand, St. John
5/9/2007	Moose Creek Reservoir	4.00	Reward®	Hand, St. John
5/10/2007	Winchester Lake	4.00	Reward®	Hand, St. John
5/10/2007	Spring Valley Reservoir	4.00	Reward®	Hand, St. John
7/27/2007	Robinson Pond	2.00	Reward®	Hand, St. John
7/27/2007	Burling Pond	0.25	Reward®	Hand, St. John
4/29/2008	Burling Pond	0.25	Reward®	Hand
4/29/2008	Robinson Pond	2.00	Reward®	Hand
4/30/2008	Spring Valley Reservoir	4.00	Reward®	Hand
4/30/2008	Winchester Lake	4.00	Reward®	Hand
6/26/2008	Robinson Pond	2.00	Reward®	Hand, Dugger
7/17/2008	Spring Valley Reservoir	4.00	Reward®	Hand, Davids
7/17/2008	Winchester Lake	4.00	Reward®	Hand, Davids
4/27/2009	Burling Pond	0.50	Reward®	Hand
4/27/2009	Fred Warren Pond	0.50	Reward®	Hand
4/29/2009	Robinson Pond	2.00	Reward®	Hand, Davids

Table 14. Temperature (˚C) and dissolved oxygen (DO; mg/L) profiles for lowland reservoirs in the Clearwater Region, Idaho, in 2009.

Deer Creek Reservoir

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	9.5	14.1	8.5	21.0	8.2	23.4	9.3	22.2	7.3	22.8	6.4	11.7	7.0	7.1
1	9.3	14.0	8.8	19.5	8.4	22.6	9.4	21.9	7.7	21.1	6.2	11.2	6.7	6.7
2	10.1	12.1	8.7	17.7	8.2	21.9	9.5	21.8	7.2	20.8	6.1	11.1	6.6	6.6
3	10.9	9.3	10.6	14.7	13.5	18.0	9.1	21.1	6.8	19.1	6.1	11.1	6.6	6.5
4	8.9	7.3	10.2	11.2	11.7	13.8	11.0	17.8	0.9	14.0	6.0	11.1	6.6	6.5
5	5.0	6.3			4.5	9.6	2.0	13.2	0.2	9.9	6.0	11.0	6.6	6.5
6	2.4	5.6			0.4	7.4	0.4	10.3	0.1	8.3	5.9	11.0	6.6	6.5
7	0.3	5.1			0.3	6.4					6.0	10.9	6.6	6.5
8	0.2	4.9			0.3	5.8					0.4	8.2	6.7	6.4
9	0.2	4.8			0.3	5.4							6.6	6.4
10					0.3	5.2							6.6	6.4
11													0.5	6.0

Elk Creek Reservoir

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	11.1	15.7	8.8	20.3	9.3	21.6	12.0	22.2	10.0	22.9	8.6	10.0	10.5	4.8
1	10.8	12.4	9.4	15.8	9.1	21.6	12.0	21.7	10.1	21.3	8.5	10.0	10.5	4.5
2	11.4	9.0	10.5	14.0	10.6	19.5	9.4	18.3	10.0	20.1	8.5	10.0	10.4	4.4
3	11.9	7.3	12.1	12.7	10.1	15.6	7.2	16.6	9.1	17.6	8.4	10.0	10.2	4.4
4	12.8	6.4	9.3	9.3	7.7	12.5	2.6	14.7	1.4	14.5	8.1	9.9	10.0	4.4
5					4.6	10.7			0.4	12.9	4.0	9.9		
6														

Mann Lake

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	9.6	17.6	10.1	21.3	8.3	24.2	10.8	25.3	11.0	25.0	9.5	12.1	10.0	8.4
1	9.9	16.0	10.2	21.0	8.1	24.1	10.0	23.6	10.4	23.5	9.6	12.2	10.0	8.2
2	9.9	15.7	10.1	20.8	8.4	23.9	9.0	22.8	9.0	22.5	9.7	12.2	10.0	8.1
3	9.4	14.8	9.9	20.6	7.7	21.5	7.4	22.0	8.1	21.8	9.7	12.2	10.0	8.0
4	8.8	12.8	7.7	19.4	6.4	20.4	6.3	21.8	7.1	21.5	9.8	12.2	9.9	7.7
5	8.5	12.5	6.4	18.2	5.3	19.7	5.7	21.5	6.3	21.1	9.7	12.1	9.9	7.6
6	8.2	12.4	5.0	17.5	4.4	19.1	7.0	21.2	6.2	21.0	9.7	12.1	9.9	7.6
7	7.9	12.3	3.7	16.5	4.0	18.8	6.6	21.0	6.4	20.7	9.6	12.1	9.8	7.6
8	7.5	12.2	3.0	15.6	3.8	18.5	5.6	20.8	5.3	20.6	9.4	12.0	9.7	7.6
9	7.5	12.1	2.6	15.0	3.3	18.3	4.5	20.7	5.1	20.3	9.0	12.0	9.6	7.6
10	7.5	12.1	2.5	14.7	1.8	18.1	0.2	20.4	4.5	20.1	2.7	11.9		
11	7.0	12.0							0.2	20.0				

Table 14 (con). Temperature (˚C) and dissolved oxygen (DO; mg/L) profiles for lowland reservoirs in the Clearwater Region, Idaho, in 2009.

Moose Creek Reservoir

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	9.3	18.1	8.4	21.4	8.2	22.3	9.3	22.5	8.2	22.4	5.4	10.3	9.8	5.7
1	9.7	17.3	9.2	20.1	8.0	22.2	9.2	21.7	8.0	20.6	5.3	10.1	9.8	5.2
2	11.5	10.8	9.8	17.9	10.4	20.5	6.4	20.8	8.2	20.4	5.1	10.1	9.8	5.1
3	11.4	8.9	8.6	13.4	8.2	15.7	1.7	18.2	5.4	16.9	5.2	10.1	9.7	5.1
4	10.8	8.3	0.6	11.7	2.3	12.4	0.4	13.9	0.3	12.9	5.2	10.0		

Robinson Pond

Depth	September		October	
(m)	DO	Temp	DO	Temp
0	10.5	22.1	11.7	11.0
1	10.1	20.2	10.4	10.6

Soldier's Meadow Reservoir

Depth	May		June		July		August		September	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	11.0	13.3	9.3	19.0	8.3	20.3	10.7	21.7	10.8	21.4
1	11.1	12.9	9.4	18.0	8.3	20.3	10.9	21.5	10.9	21.3
2	11.1	12.8	9.3	17.3	8.2	20.2	7.1	19.1	7.3	19.0
3	11.5	9.2	7.2	13.4	8.8	18.6	5.9	18.6	6.2	18.3
4	10.7	8.1	7.7	11.4	7.2	15.7	4.6	18.4	5.3	18.2
5	10.1	7.5	8.2	9.6	4.6	12.7	0.8	17.4	1.0	17.1
6	9.6	7.0	6.8	8.0	4.5	11.0	0.3	15.4	0.7	14.9
7	9.5	6.9	6.5	7.5	4.9	9.1	0.2	14.2	0.5	14.0
8	9.4	6.5	6.8	7.2	4.6	8.5	0.2	12.8	0.4	13.1
9	8.6	5.6	6.4	7.0	4.7	8.1	0.2	11.5	0.2	11.6
10	7.8	5.4	6.3	6.9	4.4	7.6	0.2	9.5	0.2	9.5
11	7.0	5.2	6.3	6.8	4.0	7.3	0.2	9.2	0.2	9.1

Spring Valley Reservoir

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	10.7	17.8	7.2	21.6	8.6	22.5	12.5	23.0	10.5	22.7	7.0	11.9	11.2	6.7
1	11.2	15.7	8.0	20.9	8.7	22.3	12.7	22.9	11.1	20.1	7.1	11.6	10.9	6.5
2	12.1	13.4	8.0	20.4	8.3	22.3	12.5	22.1	8.6	17.1	7.0	11.5	11.0	6.5
3	11.8	11.0	11.2	14.6	12.7	20.2	5.7	19.8	8.2	16.9	6.1	11.4	10.8	6.4
4	9.7	9.6	4.7	11.4	7.2	14.5	0.6	16.8	8.1	16.3	5.8	11.3	10.6	6.4
5	6.6	8.3	1.5	9.7	0.4	11.5	0.3	12.1	1.4	14.2	5.2	11.2	10.2	6.4
6	5.0	7.6	0.4	8.4	0.2	9.3	0.3	9.9	0.3	10.1	4.6	11.1	9.7	6.3
7	3.5	7.2	0.4	7.8	0.2	8.3	0.3	8.7	0.3	8.5	0.4	9.9		
8	2.0	7.0	0.4	7.9	0.2	7.7	0.3	8.3	0.1	8.1	0.4	9.1		
9					0.2	7.4								

Table 14 (con). Temperature (˚C) and dissolved oxygen (DO; mg/L) profiles for lowland reservoirs in the Clearwater Region, Idaho, in 2009.

Tolo Lake

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	8.4	17.1	8.6	19.9	8.4	21.4	17.9	22.4	8.9	20.3	8.7	9.2	11.8	6.5
1	8.5	17.2	2.8	17.2	8.4	21.3	5.8	21.2	8.9	20.2	8.7	9.1	11.8	6.5
2	7.9	14.7	0.3	15.1	7.1	20.9	0.4	20.0	8.8	20.1	8.7	9.1	11.5	6.1
3	8.0	10.9					0.3	18.2	0.2	19.9				

Waha Lake

Depth	May		June		July		August		September	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	10.7	15.5	8.6	19.8	7.7	21.4	10.4	22.0	11.3	20.9
1	10.7	15.4	8.4	19.8	7.6	21.4	11.1	20.7	12.5	19.8
2	10.7	14.8	8.8	19.1	7.7	21.3	10.9	20.0	11.8	19.6
3	11.4	9.8	8.8	17.8	9.4	19.3	10.3	18.5	11.1	18.1
4	11.1	9.2	9.2	12.3	9.0	14.2	7.0	9.3	8.0	9.0
5	11.0	9.0	9.3	9.7	6.8	10.0	6.8	7.3	7.0	6.9
6	10.6	8.4	8.7	7.9	6.7	8.0	6.9	6.7	6.8	6.3
7	10.4	7.4	8.3	7.2	6.8	7.1	7.3	6.3	6.9	5.7
8	10.3	7.2	8.4	6.6	7.0	6.6	7.6	6.0	7.0	5.5
9	10.2	6.9	8.2	6.4	7.2	6.3	8.0	5.8	6.9	5.5
10	10.1	6.6	8.4	6.2	7.3	6.1	7.7	5.6	6.4	5.4
11	10.0	6.3	8.3	5.9	7.5	5.9	7.9	5.5	6.3	5.4
12	9.9	6.0								

Winchester Lake

Depth	May		June		July		August		September		October		November	
(m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
0	16.6	16.7	14.0	20.0	12.9	21.3	7.9	21.7	9.0	21.1	4.9	10.2	7.9	6.0
1	16.7	16.5	13.9	20.0	13.1	20.9	8.4	20.4	8.9	20.9	4.8	10.2	7.9	6.0
2	16.8	13.2	5.4	17.7	6.2	18.3	5.2	19.6	7.3	20.3	4.8	10.2	7.8	5.9
3	8.8	9.5	0.3	15.1	0.3	14.0	0.3	17.7	0.9	18.9	4.8	10.2	7.7	5.9
4	8.3	8.7	0.3	10.0	0.7	12.1	0.2	14.2	0.4	16.6	4.7	10.2	7.7	5.9
5	7.7	8.2	0.2	8.7	0.8	11.8	0.2	13.7	0.3	14.8	4.7	10.2	7.7	5.9
6	7.6	8.0	0.2	8.1	0.7	11.7	0.2	13.6	0.2	14.6	4.7	10.2	7.7	5.9
7	6.9	7.7	0.2	7.7	0.2	11.5	0.2	13.5	0.2	14.4	4.7	10.1	7.7	5.9
8	5.9	7.3	0.2	7.6	0.2	10.9	0.2	12.8	0.2	13.8	3.3	10.1	7.6	5.8
9	5.5	7.3	0.2	7.8					0.2	11.7			5.9	5.7
10			0.2	7.7										
11														

Table 15. Actual volume (acre-ft), and percent of total reservoir volume available for trout by month using a 5.0 mg/L dissolved oxygen minimum, and a 21˚C upper thermal limit, for lowland lakes and reservoirs in the Clearwater Region, Idaho, during 2009.

	May		June		July		August		September		October		November	
Reservoir Name	volume	%	volume	%	volume	%	volume	%	volume	%	volume	%	volume	%
Deer Creek Reservoir	738.7	97.3	759.6	100.0	371.6	48.9	193.5	25.5	450.0	59.2	756.2	99.6	759.6	100.0
Mann Lake	1742.7	100.0	1264.8	72.6	558.2	32.0	133.8	7.7	256.1	14.7	1729.0	99.2	1247.6	71.6
Soldier's Meadow Reservoir	1555.5	100.0	1555.5	100.0	1093.0	70.3	656.6	42.2	794.9	51.1	---	---	---	---
Spring Valley Reservoir	701.2	95.3	539.8	73.4	276.8	37.6	199.9	27.2	539.8	73.4	665.3	90.4	735.6	100.0
Tolo Lake	247.5	100.0	114.8	46.4	132.6	53.6	0.0	0.0	246.8	99.7	247.5	100.0	247.5	100.0
Winchester Lake	1501.0	100.0	858.3	57.2	748.7	49.9	748.7	49.9	748.7	49.9	0.0	0.0	1501.0	100.0

Table 16. Dissolved oxygen (mg/L) levels measured in hypolimnetic aeration system in Winchester Lake, Idaho, 2003 - 2009.

Date	5m down the uptake pipe	3m down the uptake pipe	top of uptake pipe	top of return pipe	3m down the return pipe	5m down the return pipe	Change in DO
Jul-03	0.6	0.9	1.2	1.5	1.7	1.7	**1.1**
Aug-03	0.8	1.3	1.6	2.0	2.1	2.2	**1.5**
Sep-03	4.5	4.6	5.0	4.9	4.8	4.7	**0.3**
Oct-03	5.4	5.5	5.8	5.9	5.8	5.8	**0.5**
Jun-04	3.5	3.7	3.9	4.3	4.4	4.4	**0.9**
Jul-04	0.7	1.1	1.5	1.7	1.6	1.6	**0.8**
Aug-04	0.4	0.8	1.2	1.7	1.5	1.7	**1.3**
Sep-04	6.1	6.7	6.9	6.9	6.8	6.7	**0.6**
Oct-04	4.9	5.1	5.4	5.5	5.5	5.4	**0.5**
Apr-05	9.1	9.6	10.0	10.2	10.1	10.1	**1.0**
May-05	1.8	2.3	2.6	2.8	2.8	2.7	**0.9**
Jun-05	0.6	0.9	1.3	1.6	1.7	1.7	**1.1**
Jul-05	0.2	0.6	0.9	1.1	1.0	0.8	**0.6**
Aug-05	0.5	1.2	1.5	1.8	1.7	1.6	**1.1**
Sep-05	3.8	4.1	4.6	5.0	4.8	4.8	**1.1**
Oct-05	8.5	8.6	9.0	9.2	9.1	9.1	**0.6**
Nov-05	10.1	10.8	11.5	11.6	11.7	11.7	**1.6**
Feb-06	6.4	7.3	7.8	8.3	8.4	8.4	**2.0**
Mar-06	6.9	7.0	7.8	8.2	8.2	8.2	**1.3**
Apr-06	7.5	8.1	8.1	8.8	8.9	8.8	**1.3**
May-06	5.8	6.5	7.4	7.4	7.4	7.3	**1.6**
Jun-06	4.5	5.0	5.8	5.8	5.8	5.7	**1.3**
Jul-06	0.8	1.3	1.6	1.5	1.4	1.3	**0.5**
Aug-06	0.4	0.6	0.9	0.8	0.7	0.7	**0.3**
Sep-06	3.5	4.5	4.9	4.9	4.9	4.9	**1.4**
Oct-06	8.2	9.1	9.9	9.9	9.9	9.8	**1.7**
Apr-07	9.3	9.6	10.5	10.6	10.6	10.6	**1.3**
May-07	0.3	0.8	1.1	1.2	1.1	1.1	**0.8**
Jun-07	0.2	0.7	1.0	1.0	0.9	0.8	**0.6**
Jul-07	0.4	0.4	0.9	1.0	0.9	0.8	**0.5**
Aug-07	0.3	0.4	1.2	1.2	1.2	1.1	**0.8**
Sep-07	3.8	4.2	4.8	4.8	4.8	4.8	**0.9**
Oct-07	6.3	6.9	7.0	7.0	7.0	6.9	**0.7**
May-08	0.9	1.2	1.3	1.3	1.3	1.3	**0.4**
Jun-08	0.3	0.4	0.6	0.6	0.5	0.5	**0.2**
Jul-08	0.1	0.6	0.9	0.8	0.7	0.6	**0.5**
Aug-08	0.4	0.7	1.2	1.1	1.0	0.9	**0.6**
Sep-08	1.7	1.9	2.1	2.6	2.5	2.5	**0.8**
Oct-08	6.0	6.8	7.3	7.4	7.4	7.4	**1.4**
May-09	7.5	8.2	8.6	8.6	8.5	8.3	**0.8**
Jun-09	0.2	0.2	0.4	0.5	0.4	0.4	**0.2**
Jul-09	0.8	0.9	1.2	1.3	1.3	1.3	**0.5**
Aug-09	0.2	0.6	0.9	1.0	0.9	0.7	**0.5**
Sep-09	0.2	0.7	0.8	0.9	0.7	0.5	**0.3**
Oct-09	4.5	4.8	5.5	5.9	5.7	5.7	**1.2**
Nov-09	7.6	7.8	8.2	8.8	8.8	8.9	**1.3**

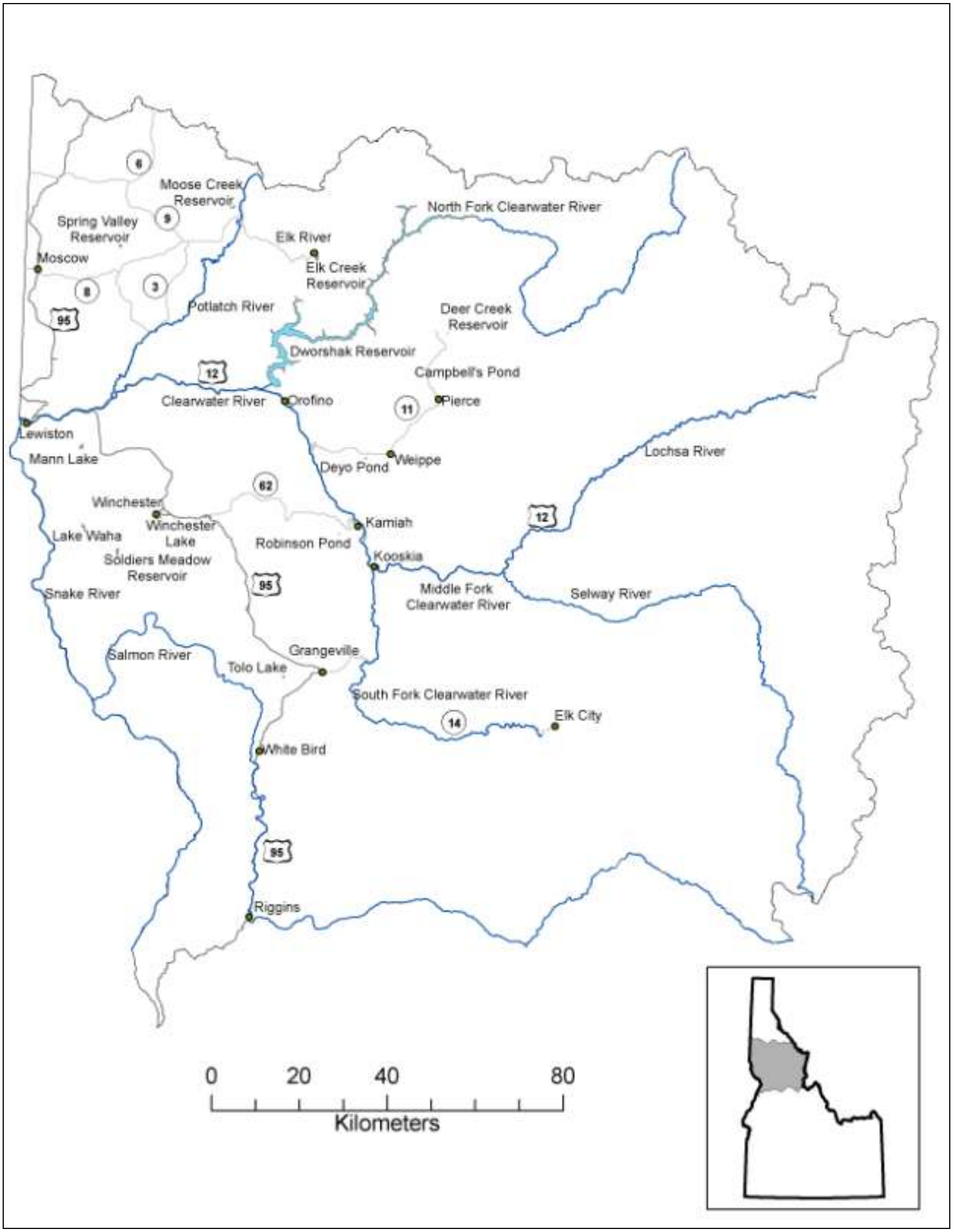
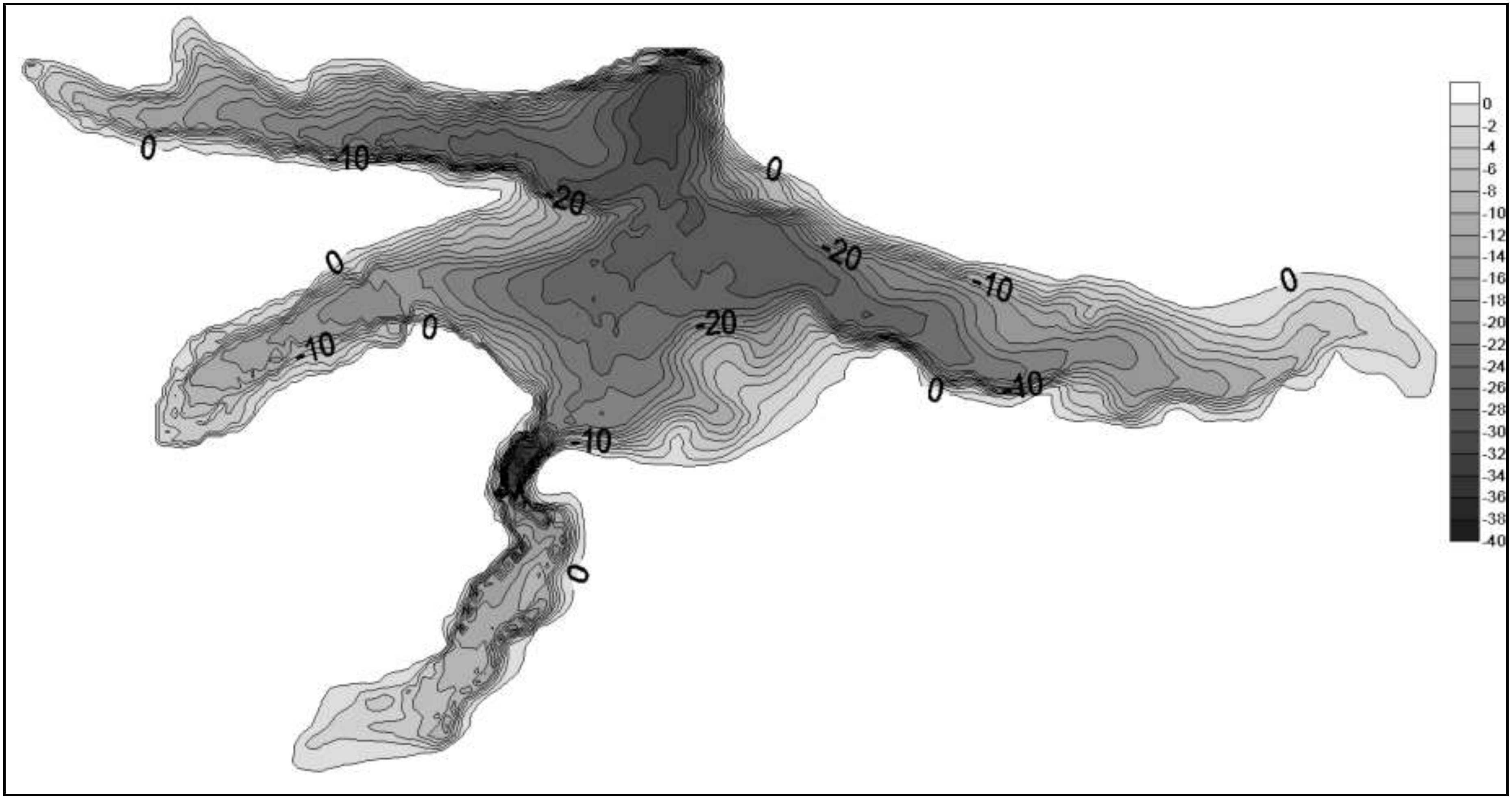


Figure 19. Map of lowland lakes and reservoirs in the Clearwater Region, Idaho.

Figure 20. Bathymetric map (depth in feet) of Winchester Lake, Idaho, in 2009.



2009 Clearwater Region Annual Fishery Management Report

Reservoir Investigations

ABSTRACT

Regional lowland lakes and reservoirs were stocked with approximately 156,900 fingerling rainbow trout *Oncorhynchus mykiss*, 230,496 catchable rainbow trout, and 4,200 channel catfish *Ictalurus punctatus* to enhance resident fish populations and provide additional harvest opportunities.

Impromptu angler surveys were conducted on regional reservoirs, with a total of 972 anglers surveyed. The anglers fished for 2,009.5 hours, and caught 3,947 fish, for an average catch rate of 1.96 fish/hr. The overall catch rate for trout was 1.25 fish/hr, well above the 0.5 fish/hr management goal.

In Dworshak Reservoir, a total of 269 smallmouth bass *Micropterus dolomieu* ranging in length from 70 - 439 mm were collected in 22,390 seconds of electrofishing. This survey does a good job of collecting smaller size fish which frequent the shoreline. However, sampling experience and numerous discussions with anglers indicate that larger fish (over 350 mm) in Dworshak Reservoir prefer deeper water. Future sampling should be conducted at different times to provide information on factors that may be influencing our catch, and “deep cathode” electrofishing should be evaluated.

Angler exploitation rates for rainbow trout were evaluated in Dworshak Reservoir to determine if changes were needed due to the perception that return rates were low for these stockings. The exploitation rate was calculated to be 1.8%, well below the 40.0% expected for put and take waters. This indicates a need to modify or eliminate this stocking.

An electrofishing survey of Deer Creek Reservoir was conducted to determine length frequency distributions. A total of 187 trout were collected ranging in length from 150 - 329 mm. Three westslope cutthroat trout *Oncorhynchus clarkii lewisi* were collected as well.

Standard lowland lake surveys of Elk Creek Reservoir, Moose Creek Reservoir, Soldiers Meadows Reservoir were conducted in the spring of 2009. Additionally, a census mark-recapture experiment was conducted on Moose Creek Reservoir to develop a population estimate for largemouth bass *M. salmoides*. Elk Creek Reservoir continues to show declines in numbers of largemouth bass combined with increases in prey species. However, the bass have seen shifts towards larger sizes. Moose Creek Reservoir appears to have a healthy largemouth bass population in spite of a widespread infestation of curly-leaf pondweed *Potamogeton crispus*. Of the largemouth bass collected 9.1% were over 450 mm in length. Mark-recapture sampling resulted in the collection of 589 largemouth bass in Moose Creek Reservoir, ranging in length from 100 - 558 mm. Statistical analysis provided a population estimate of 893 fish (81.9 fish/ha), and an estimate of 194 fish over 300 mm in length. Soldier’s Meadow Reservoir continues to be dominated by small black crappie *Pomoxis nigromaculatus* and brown bullhead *Ampiurus nebulosus.*

Author:

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Regional Fishery Biologist

INTRODUCTION

Idaho's Clearwater Region has a substantial diversity of fishing opportunities. However, many of these fisheries are restrictive in nature due to unique fish populations or geography (e.g. large rivers with anadromous fisheries, high elevation rivers and streams managed with restrictive regulations to manage wild cutthroat trout populations, and mountain lakes with difficult access). Because of these restrictive regulations and access, the lowland lake program has been designed and managed to provide additional fishing and harvest opportunities with easy access. A 2003 statewide economic survey (IDFG 2005), and regional creel surveys (Hand 2009) indicate that the lowland lakes in the Clearwater Region account for over $3.6 million in economic value to the region (in 2003), and approximately 148,065 hours (average of surveys conducted in 1993, 1999, and 2005) of fishing effort annually. Due to the high economic and recreational importance of these fisheries, managing this program is a priority for the Clearwater Region fisheries staff.

The regional hatchery trout program is primarily contained within the lowland lake program. This is due to the general failure of stocking hatchery trout in rivers and streams to meet pressure demands, and the low return to creel that makes these stockings economically unfeasible. As part of the lowland lake program, hatchery trout provide an easily accessible harvest opportunity, they create an "instant" fishery when they are stocked, and they meet very high angler demand in areas where natural reproduction is unable to match the harvest pressure. Catchable size (203 mm - 254 mm) hatchery rainbow trout are stocked at the times and places where they will be most available to anglers. They are the primary fishery in the lowland lake program, and are managed with a goal of maintaining a catch rate of 0.5 fish/hour for all fish in each lake (IDFG 2007). In 2005, catch rates for hatchery trout alone in individual lakes ranged from 0.8 - 1.5 fish/hour, all above the 0.5 fish/hour overall catch rate goal for lowland lakes. Creel survey results have shown they account for an average of 72.3% of the fish harvested from the region's lowland lakes (Hand 2009).

In addition to hatchery catchable trout, fingerling trout are also stocked in our lowland lakes and reservoirs. The fingerling program is funded by the Lower Snake River Compensation Plan as mitigation for the loss of fisheries due to the construction of the lower Snake River dams. By stocking fingerling trout, we can utilize the natural production that occurs in the lakes to facilitate a put-grow-take fishery. Because these fish are raised in a natural setting, they are often a more desirable fish for anglers. Although these fish return to the creel at lower rates than the catchables, they are substantially cheaper to stock. Fingerling rainbow trout are stocked in most of the area lowland lakes. Additionally, fingerling westslope cutthroat trout are stocked in Deer Creek Reservoir to provide diversity of opportunity.

The lowland lakes in the Clearwater Region also provide excellent fishing opportunities for warmwater species such as largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieu*, yellow perch *Perca flavescens*, bluegill *Lepomis macrochirus*, pumpkinseed *L. gibbosus*, crappie *Pomoxis sp.*, channel catfish *Ictalurus punctatus*, and brown bullhead *Ampiurus nebulosus*. Tiger muskie, a cross between northern pike and muskellunge, have been stocked into Winchester Lake and Spring Valley Reservoir to provide a trophy component in the lowland lake program. Largemouth bass in the region are managed to provide a diversity of opportunity based on the fishery each body of water is capable of producing.

In order to better manage these fisheries, we conducted standardized lowland lake surveys on a three year rotation, and an annual smallmouth bass survey of Dworshak Reservoir. The fish population information collected from these surveys, in conjunction with angler information collected from creel surveys, is used to develop our management strategies for these lakes and reservoirs, and will be used as baseline data for future management decisions and projects such as macrophyte control or fish removal.

OBJECTIVES

1. Evaluate angler exploitation rates of hatchery catchable trout in regional reservoirs.

2. Transfer largemouth bass from Winchester Lake to Soldier's Meadow Reservoir and Tolo Lake to re-establish predator population and fishery in these two reservoirs.

3. Conduct impromptu angler surveys at regional reservoirs to provide information on catch rates in years between year-long creel surveys.

4. Conduct standard smallmouth bass survey on Dworshak Reservoir to provide population information needed to direct management of bass in this reservoir.

5. Assess over-winter survival and growth of trout on Deer Creek Reservoir.

6. Conduct standard lowland lake surveys of Moose Creek Reservoir, Elk Creek Reservoir, and Soldier's Meadow Reservoir to provide population information needed to direct management of these reservoirs.

7. Develop population estimates for largemouth bass in Moose Creek Reservoir to provide additional population information for making management decisions.

STUDY AREAS

These projects were conducted on reservoirs and ponds in Idaho's Clearwater Region, located in the north-central area of the state (Figure 21). Hatchery fish stockings occurred on many reservoirs, ponds, and streams throughout the region. The fish transfers were conducted on regional lowland lakes.

Deer Creek Reservoir is a 30.2 ha reservoir located in Clearwater County near the town of Headquarters, Idaho at an elevation of 1,006 m (Figure 21). Completed in 2003, it is the newest IDFG reservoir in the state of Idaho.

Elk Creek Reservoir is an 18.7 ha reservoir located in Clearwater County 3.2 km southeast of Elk River, Idaho at an elevation of 945 m (Figure 21). Potlatch Corporation originally constructed Elk Creek Reservoir as a log-holding pond. The original dam washed out in 1937 and was reconstructed in 1950. The reservoir was chemically treated in October 1950 prior to refill. The IDFG reconstructed the dam and spillway most recently in 1987. IDFG owns the land surrounding Elk Creek Reservoir, and the Elk River Recreation District leases the land for recreation management such as fishing, swimming, overnight camping, and organized boat races. The reservoir holds 111 ha-m of water at full pool.

Moose Creek Reservoir is a 10.9 ha reservoir located in Latah County 12.9 km northwest of Bovill, Idaho at an elevation of 878 m (Figure 21). The reservoir has a maximum depth of 3.9 m with approximately 90% of the reservoir less than 2.4 m deep. During the summer, a large portion (80-90%) is densely vegetated with a growth of aquatic macrophytes. The reservoir was drained and dredged in 1999. Moose Creek Reservoir is the site of an abandoned clay mining operation. The reservoir is located on land owned by the Idaho Department of Lands, but is managed by IDFG through a memorandum of agreement (MOU). IDFG also has an MOU with Latah County Recreation District to manage camping and day-use recreation on approximately 28 ha surrounding the reservoir.

Refer to Hand et al. (2011) for descriptions of Soldier's Meadow Reservoir and Dworshak Reservoir.

METHODS

Angler exploitation rates were calculated for Dworshak Reservoir using methodology described in Mamer et al. 2008. Two hundred rainbow trout were tagged and released in Dworshak Reservoir. Tagging, data entry and analysis was conducted based on the protocols of the IDFG "Tag You're It"/Fish Data Base program (Mamer et. al 2008).

Impromptu angler surveys were conducted on lowland reservoirs several times on both weekdays and weekends. Surveys consisted of interviewing all anglers at each reservoir and recording number of anglers, number of hours spent fishing, and number of fish caught and harvested by species. CPUE refers to the number of fish caught/hours fished.

An electrofishing survey of Deer Creek Reservoir was conducted to assess over-winter survival and growth of rainbow trout and westslope cutthroat trout. Data was taken from one hour of electrofishing along the shoreline starting at the boat dock and travelling counter-clockwise.

Methodology for fish transfers, Dworshak Reservoir smallmouth bass surveys, standard lowland lake surveys, largemouth bass population estimates, and the development of age-frequency distributions and catch curves for estimating mortality can be found in Hand et al. (2011). Figure 22 shows the locations of smallmouth bass surveys conducted in Dworshak Reservoir.

RESULTS

Angler Exploitation Surveys

Major changes were made to the stocking request list in 2009, for stockings beginning in 2010. The total number of fish stocked in the region, and number stocked by each hatchery did not change. Angler exploitation rates were evaluated in Dworshak Reservoir to determine if changes were needed due to the perception that return rates were low for these stockings. The exploitation rate was calculated to be 1.8%, well below the minimum 40.0% expected for put and take waters.

Fish Transfers

A total of 198 largemouth bass were transferred from Winchester Lake to Soldier's Meadow Reservoir (Figure 23), and 203 largemouth bass were transferred from Winchester Lake to Tolo Lake (Figure 24). These fish ranged in length from 100 - 305 mm.

Impromptu Angler Surveys

Impromptu angler surveys were conducted on regional reservoirs several times during the year (Table 17). A total of 972 anglers were surveyed, accounting for 2,009.5 hours fished, and 3,947 fish caught. Of the fish caught, 2,310 were rainbow trout, 791 bluegill, 435 black crappie *P. nigromaculatus*, 158 largemouth bass, 105 yellow perch, 31 pumpkinseed, 22 brook trout, and three smallmouth bass. Catch rates for hatchery rainbow trout ranged from 0.80 fish/hr at Soldier's Meadow reservoir to 2.22 fish/hr at Waha Lake. The average catch rate for hatchery trout for all lowland reservoirs was 1.15 fish/hr. Catch rates for all fish combined ranged from a low of 0.87 fish/hr at Soldier's Meadow Reservoir to a high of 3.19 fish/hr at Mann Lake. The average catch rate for all fish in all lowland reservoirs was 1.96 fish/hr.

Dworshak Reservoir Smallmouth Bass Survey

An annual smallmouth bass monitoring survey was conducted on Dworshak Reservoir from June 1 - 2, 2009. A total of 269 smallmouth bass ranging in length from 70 - 439 mm (Figure 25) were collected in 22,390 seconds of electrofishing. The 269 fish collected were the most since 1994 (Figure 26), while the catch rate of 43.3 fish/hr was the highest since 2003. Smallmouth bass PSD (Anderson 1980) was 6.7 in 2009 (Figure 27), a decrease from 16.9 in 2008 and the second lowest since 1998.

Scale samples were collected from 78 of the smallmouth bass collected in 2009 for age and growth analysis. Of these, ages could be determined for 76 fish. Fish collected ranged in age from 2 - 7 (Table 18). They did not reach stock size of 180 mm (Gablehouse 1984) until age four and quality size of 280 mm until age six. Annual growth rates ranged from 39 - 69 mm.

An age-frequency distribution (Table 19) was compiled to assist in the development of a catch curve for estimating mortality (Miranda and Bettoli 2007). The catch curve was used to estimate annual mortality for smallmouth bass collected in 2009 (Figure 28). Annual instantaneous mortality (Z) was $Z = -0.9828$ ($R^2 = 0.9358$) for fish aged 3 - 7. Thus, the annual survival rate (S) was 37.4%, and the total annual mortality (AM) was 62.6%.

Deer Creek Reservoir Trout Survey

An electrofishing survey of Deer Creek Reservoir was conducted on May 25, 2009 to assess over-winter survival and growth of stocked rainbow trout and westslope cutthroat trout. This survey was done pre-stocking, thus all fish collected were carry-overs from the 15,000 catchable rainbow trout stocked in 2008 and 4,994 fingerling westslope cutthroat trout stocked in 2007 (none were stocked in 2008). One hour of electrofishing resulted in the capture of 184 rainbow trout ranging in length from 150 - 329 mm (Figure 29). Additionally, three westslope cutthroat trout were captured, ranging in length from 270 - 279 mm. The westslope cutthroat trout were stocked as fingerlings. No golden shiners *Notemigonus crysoleucas* were collected during this sampling.

Standard Lake Surveys

Elk Creek Reservoir

A standard lake survey of Elk Creek Reservoir was conducted on May 27, 2009. A total of 3,600 seconds of electrofishing resulted in the capture of 341 fish, including largemouth bass (N = 27), smallmouth bass (N = 26), brook trout (N = 14), brown bullhead (N = 36), pumpkinseed (N = 152), black crappie (N = 77), and bluegill (N = 9). A comparison of catch per unit effort (CPUE) between samples collected from 1997 - 2009 is shown in Figure 30.

Smallmouth bass collected ranged from 112 - 456 mm in length (Figure 31), with most of the fish collected in the 200 - 290 mm range. Smallmouth bass PSD (Anderson 1980) was 31.8 in 2009, a drop from 33.3 in 2005 and 39.3 in 2006. Scale samples were analyzed from smallmouth bass collected in 2005 and 2009. Smallmouth bass ranged in age from 1 - 6 years in 2005, and 1 - 8 years in 2009 (Table 20). Annual growth rates ranged from 60 - 88 mm in 2005 and from 37 - 79 mm in 2009. A catch curve could not be developed for either 2005 or 2009 due to not having enough fish in each age class for calculations.

Largemouth bass collected ranged from 100 - 459 mm in length (Figure 32), with most of the fish collected in the 275 – 375 mm range. Largemouth bass PSD (Anderson 1980) was 70.4 in 2009, the highest recorded since 1995. Scale samples were analyzed from largemouth bass collected in 2005 and 2009. Largemouth bass ranged in age from 3 - 6 years in 2005, and 1 - 6 years in 2009 (Table 21). Annual growth rates ranged from 63 - 102 mm in 2005 and from 38 - 77 mm in 2009. A catch curve could not be developed for either 2005 or 2009 due to not having enough fish in each age class for calculations.

Pumpkinseed collected ranged from 43 - 175 mm in length (Figure 33), with most of the fish collected in the 80 - 150 mm range. Scale samples were analyzed from pumpkinseed collected in 2009. Pumpkinseed ranged in age from 1 - 5 years (Table 22). Annual growth rates ranged from 9 - 26 mm. A catch curve could not be developed because more older fish than younger fish collected.

Black crappie ranged in length from 80 - 259 mm (Figure 34), with almost all of them over 140 mm, continuing the shift toward larger fish. The number of black crappie collected decreased substantially in 2009; however, the size has increased considerably. Scale samples were analyzed from black crappie collected in 2009. Black crappie ranged in age from 1 - 7 in 2009 (Table 23). Annual growth rates ranged from 15 - 37 mm. A catch curve could not be developed because larger numbers of older fish than younger fish were collected.

Brown bullhead ranged in length from 130 - 324 mm (Figure 35). Bluegill ranged in length from 50 - 160 mm.

Moose Creek Reservoir

Clearwater Region fisheries management personnel conducted a standard lake survey of Moose Creek Reservoir on May 26, 2009. This survey resulted in the capture of 194 fish, including bluegill (N = 85), black crappie (N = 25), brown bullhead (N = 4), pumpkinseed (N = 16), and largemouth bass (N = 64). A comparison of catch per unit effort between samples collected from 2001 - 2009 is shown in Figure 36.

Largemouth bass collected ranged from 120 - 539 mm in length (Figure 37), with most of the fish collected in the 180 - 309 mm range. Nine fish collected were over 450 mm in length. Largemouth bass PSD (Anderson 1980) was 30.0 in 2009, the second lowest since 2001 and well below the 58.1 seen in 2006. Scale samples were analyzed from largemouth bass collected in 2004 and 2009. They ranged in age from 1 - 5 years in 2004, and 2 - 10 years in 2009 (Table 24). Annual growth rates ranged from 53 - 99 mm in 2004 and from 25 - 55 mm in 2009. A catch curve could not be developed for either 2004 or 2009 due to not having enough fish in each age class for calculations.

Bluegill collected ranged from 50 - 259 mm in length (Figure 38), with most fish in the 90 - 169 mm range. Bluegill CPUE (fish/hr), while well below the 2006 sample, continues to show an overall upward trend. PSD is also rising, from 7.1 2006 to 25.6 in 2009. Scale samples were analyzed from bluegill collected in 2004. Bluegill ranged in age from 1 - 3 years (Table 25). Annual growth rates ranged from 50 mm - 52 mm. A catch curve could not be developed for 2004 due to not having enough fish in each age class for calculations.

Black crappie collected ranged from 130 - 240 mm in length (Figure 39). Black crappie PSD remained high and steady, at 78.6. CPUE (fish/hr) increased from 2006 to 2009, yet numbers remain low. Scale samples were analyzed from black crappie collected in 2004 and 2009. Black crappie ranged in age from 3 - 5 years in 2004, and 3 - 8 years in 2009 (Table 26). Annual growth rates ranged from 32 mm - 40 mm in 2004, and from 7 mm - 41 mm in 2009. Catch curves could not be developed for 2004 or 2009 due to not having enough fish in each age class for calculations.

Pumpkinseed collected ranged from 80 - 149 mm in length. PSD, which had not been above 8.3 since 2004, dropped to 0.0 in 2009. Scale samples were analyzed from pumpkinseed collected in 2004 and 2009. Pumpkinseed ranged in age from 3 - 6 years in 2009 (Table 27). Annual growth rates ranged from 9 mm - 25 mm. A catch curve could not be developed for 2009 due to not having enough fish in each age class for calculations. Although pumpkinseed were collected in 2004, no scales were collected for analysis.

Soldier's Meadow Reservoir

Clearwater Region fisheries management personnel conducted a standard lake survey of Soldiers Meadow Reservoir on June 3, 2009. This survey resulted in a capture of 396 fish, including black crappie (N = 12), brown bullhead (N = 261), yellow perch (N = 111), and largemouth bass (N = 7). A comparison of catch per unit effort between samples collected in 2003, 2005, and 2009 is shown in Figure 40.

Yellow perch collected ranged from 60 - 199 mm in length (Figure 41). This is the first time yellow perch have been sampled in the reservoir. Scale samples were analyzed from yellow perch collected in 2009. They ranged in age from 1 - 4 years (Table 28). Annual growth rates ranged from 18 mm - 35 mm. An age-frequency distribution (Table 29) was compiled to assist in the development of a catch curve (Figure 42) for estimating mortality (Miranda and Bettoli 2007). Annual instantaneous mortality (Z) was Z = -0.6318 for fish aged 2 - 4 (R^2 = 0.9763). Thus, the annual survival rate (S) was 53.2%, and total annual mortality (A) was 46.8%.

Black crappie collected ranged from 50 - 219 mm in length (Figure 43). Black crappie PSD (Anderson 1980) remained high at 45.5, however, CPUE (fish/hr) has declined over the last three samples. Scale samples were analyzed from black crappie collected in 2005 and

2009. Black crappie ranged in age from 2 - 6 years in 2005, and 2 - 5 years in 2009 (Table 30). Annual growth rates ranged from 17 mm - 43 mm in 2005, and 14 mm - 36 mm in 2009. Catch curves could not be developed for 2005 or 2009 due to not having enough fish in each age class for calculations.

Largemouth bass collected ranged from 110 - 279 mm in length, with numbers remaining very low. A total of only nine fish have been collected in three samples. Scale samples were analyzed from largemouth bass collected in 2009 (Table 31). Largemouth bass ranged in age from 4 - 6 years. Annual growth rates ranged from 20 mm - 44 mm.

Brown bullhead collected ranged from 120 - 189 mm in length (Figure 44). Bullhead catch rates (fish/hr) continue to increase dramatically, from 55 fish/hr in 2003 to 253 fish/hr in 2009.

Waha Lake

Scale samples were analyzed from smallmouth bass collected in 2003 and 2004 (Table 32). Smallmouth bass ranged in age from 1 - 4 years in 2003, and 1 - 3 years in 2004. Annual growth rates ranged from 10 - 54 mm in 2003, and from 49 - 78 mm in 2004. An age-frequency distribution (Table 33) was compiled to assist in the development of a catch curve (Figure 45) for estimating mortality (Miranda and Bettoli 2007). Annual instantaneous mortality (Z) was Z = -0.8716 for fish aged 1 - 4 (R^2 = 0.9777). Thus, the annual survival rate (S) was 41.8%, and total annual mortality (A) was 58.2%. A catch curve could not be developed for 2004 due to not having enough fish in each age class for calculations.

Population Estimate

Moose Creek Reservoir

A total of 26,840 seconds of electrofishing resulted in the capture of 454 largemouth bass during the study period, plus 135 recaptures. This is a catch rate of 79.0 fish/hour. These fish ranged from 100 - 558 mm in total length (Figure 46). Of the largemouth bass collected, 52.4% were less than 250 mm in length, and the PSD was 26.7.

Using the Schnabel multiple-census method, a population estimate of 893 fish (Table 34), or 81.9 fish/ha was calculated. The 95% confidence intervals give upper and lower bounds of 764 and 1,075 fish (14.4% and 20.3% error). The population estimate for fish over 300 mm in length was calculated as 194 fish, with 95% confidence intervals of 142 and 305 fish (26.7% and 57.2% error). The confidence intervals for fish over 300 mm have much higher error due to the smaller sample size (N = 99).

DISCUSSION

Angler Exploitation Surveys

The extremely low angler exploitation rate from Dworshak Reservoir indicates these fish are not meeting the mitigation needs and management goal of 40% return to creel. Therefore, this stocking needs to be modified or eliminated. Other options, such as stocking in nearby ponds and reservoirs should be considered, keeping in mind that mitigation requirements stipulate that these fish must be stocked in the North Fork Clearwater River watershed.

Fish Transfers

Largemouth bass transfers to Soldier's Meadow Reservoir and Tolo Lake are an attempt to redevelop the bass fisheries in these two reservoirs. The transfers to Soldier's Meadow Reservoir will not be continued, as these stockings are meeting with little success and potential management changes may occur in the next few years. This could include renovating the reservoir to eliminate the overpopulation of introduced brown bullhead and reestablishing a fishery most acceptable to the public.

Impromptu Creel Surveys

Catch rates from impromptu creel surveys indicate that we are meeting our management goal of 0.5 fish/hr for catchable rainbow trout stockings in all of our regional reservoirs.

Dworshak Reservoir Smallmouth Bass Survey

The total annual mortality rate (AM) for the 2009 sample was 62.6%, higher than the 45.6% and 49.7% calculated for the 2004 and 2007 samples (Hand et al. 2011). As discussed in Hand et al. (2011), this survey does a good job of collecting smaller size fish which frequent the shoreline. However, experience from sampling and numerous discussions with anglers indicate that larger fish (over 350 mm) in Dworshak Reservoir prefer deeper water. Since we are not effectively sampling the entire population of smallmouth bass, our catch curves are over-estimating mortality, thus making this information unreliable.

Thus, we do not believe this survey, as it was conducted, provided an accurate representation of the population. In coming years, sampling should be conducted several different times during the spring to provide some insight into factors that may influence our catch. Several addition studies could provide information that would improve our sampling, including the evaluation of "deep cathode" electrofishing methods to collect fish in deeper water, and telemetry to provide information on seasonal and diel movements of smallmouth bass.

Length-at-age data was calculated using scales to look at potential changes in growth rates over time. Growth rates for fish aged 1 - 7 were similar to those seen in 2004 - 2008. Length-at-age was lower for fish age 1 - 5 in 2009 than in previous years, but was similar for ages 6 - 7. This could indicate reduced growth rates for younger fish, or be a product of errors in scale aging. Scale aging errors can result in incorrect estimates of growth and mortality rates, potentially leading managers to make poor management decisions. Future scale aging should include two independent readings of each scale with a third reader assisting when a consensus cannot be reached by the first two readers. Growth rates were steady for fish age 1 - 5, then increased as the fish reached age 6 - 7. The data suggests that smallmouth bass in Dworshak Reservoir grow faster as they get bigger, possibly due to a diet switch from insects and crayfish to kokanee, changes in weather patterns, and improvement in growth due to an ongoing nutrient enhancement project (Wilson et al. 2009). This nutrient enhancement project, started in 2006, was designed to improve kokanee growth. It has increased zooplankton densities which should improve growth of young fish and provide more abundant food for larger bass in the reservoir. This would result in improved growth rates. A larger sample size, including larger numbers of older fish is needed to improve our age and growth information. Collecting scales from fish caught by tournament anglers could provide additional large fish for analysis.

Although the 269 fish collected in 2009 was the most since 1994, PSD was among the lowest since sampling began in 1993. This is because only four of the 269 fish exceeded 300 mm in length. The highly fluctuating PSD's observed over time are likely due to sampling during different conditions, such as water temperature, reservoir elevation, moon phase, etc.

Deer Creek Reservoir Trout Survey

Deer Creek Reservoir continues to provide an excellent trout fishery. The CPUE of 184 fish/hr from electrofishing indicates a high level of overwinter survival, which has resulted in more large fish in the spring. The growth of these fish from the previous year is unknown, as length data at time of stocking is not recorded. The capture of several westslope cutthroat trout shows that fish stocked as fingerlings can survive and grow quickly in the reservoir. However, capturing only three fish stocked suggests carryover is poor compared to catchables, which the data suggests are surviving well. Transitioning this reservoir to a fingerling only program is a possibility, one that would provide a more desirable product, and reduce costs in the hatchery program. However, based on this data, the catchable program appears to be working better.

Standard Lake Surveys

Elk Creek Reservoir

Catch rates of both largemouth and smallmouth bass continue to decline from previous samples. These declines, combined with the increases in prey species over the last few samples could be an indication of overharvest or foraging problems associated with the large amounts of aquatic vegetation found in the reservoir (Bettolli et al. 1992; Dibble et al. 1996). These extensive, dense mats of elodea *Elodea canadensis* and filamentous algae that grow in the upper third of the reservoir are a nuisance for those using the reservoir for recreation. However, both species of bass have seen shifts in length frequency distribution towards larger fish, which is not usually seen with over-harvesting.

Also of concern is the lack of any largemouth bass collected under 220 mm in length, especially after numerous smaller fish were collected in the two previous samples. This could be the result of predation by other species in the reservoir. Bullhead numbers have been increasing, while pumpkinseed numbers dropped for the first time since 1997. Black crappie, while not increasing in physical numbers, has shown a steady shift toward larger sizes. This could result in increased predation on eggs and juvenile bass; thus, causing or contributing to recruitment failure (Leonard et al 2010).

Moose Creek Reservoir

In recent years, Moose Creek Reservoir has seen mostly stable fish populations. Only bluegill have shown a major change, increasing steadily from 18 to 101 fish/hour collected by electrofishing. In 2008, a wide variety of information was analyzed to determine what, if anything needs to be done to improve the recreational fishery in this reservoir.

Bluegills appear to be growing quickly, with fish reaching an average of 142 mm at age three in the 2004 sample. However, over the last five samples (2001 - 2009), only four of 635 fish (0.6%) collected have reached preferred size of 200 mm (Gablehouse 1984). Overharvest of larger fish can cause the appearance of stunting in populations, but with an estimated 1,401 bluegill harvested in the 2005 creel survey (Hand 2009), cropping of larger fish may be occurring.

Black crappie in the reservoir appear to have highly variable recruitment, as is common in small reservoirs (Beam 1983; McDonough and Buchanan 1991; Allen 1997). One of the primary characteristics of crappie populations in ponds and reservoirs is the cyclical nature of their abundance, with strong year classes occurring at intervals of approximately every 3 - 5 years (Swingle and Swingle 1967; Beam 1983). In the 2004 sample, only age 3 - 5 fish were collected, with almost all fish being age four. In the 2009 sample the fish collected were age 3 – 8 with three strong age classes. These age distributions indicate one to three strong year classes followed by several years of little or no recruitment, fitting the pattern discussed by Swingle and Swingle (1967) and Beam (1983). A catch curve could not be developed to estimate mortality rates for the 2004 due to more older fish captured than younger fish. This is due to 1) gear bias from the use of boat electrofishing, which tends to under-sample smaller (i.e. younger) fish; and 2) variable recruitment which makes mortality estimates difficult when few age groups are available for analysis and is also a violation of the assumption that recruitment is consistent from year to year.

The largemouth bass population in Moose Creek Reservoir continues to have a wide length frequency distribution and numerous larger fish. Of the 518 fish collected by electrofishing, 53.5% were smaller than 250 mm. The PSD dropped to 27.1 in 2009, which is below the range of 40 - 70 considered indicative of a population in balance (Anderson 1980). However, 47 fish (9.1%) were over 450 mm, and the population estimate of fish over 300 mm is 21.7% of the total population estimate. This indicates that there is likely little harvest of larger fish. Light harvest of predators by anglers results in reduced competition, increased food resources available for the remaining predators, and helps maintain good predator-prey balance (Swingle 1950; Flickinger and Bulow 1993). However, the 2005 creel surveys estimated at only 36 largemouth bass were harvested from Moose Creek Reservoir (Hand 2009; Hand and Schriever 2009). Additionally, creel surveys in 1993 and 1999 estimated no bass were harvested. Based on the population estimate of 893 fish, this suggests only a 4.0% harvest rate. This exploitation rate is well below the average rate found by Allen et al. (2008) in a study looking at 36 largemouth bass populations across the country from 1990 - 2003. High levels of exploitation of larger fish can result in a population with many smaller fish and few large fish. In contrast to Spring Valley Reservoir, this does not appear to be a problem in Moose Creek Reservoir.

Annual growth rates (Table 18) and average length-at-age are very different for the 2004 and 2009 samples. Fish in the 2004 sample had much higher annual growth and length at age. Since this occurs at almost every age, this may indicate an actual reduction in growth rates or problems with correct ageing of the fish. Future samples need to be larger and have two independent readings to ensure better accuracy. Larger sample sizes will also improve our ability to develop catch curves and estimate annual mortality.

Based on this information, it would appear that the fish populations in Moose Creek Reservoir are doing well. However, the steady expansion of dense mats of curly-leaf pondweed *Potamogeton crispus* that is growing in Moose Creek Reservoir through the summer and fall could eventually reduce forage success for predators such as largemouth bass, and increase the abundance of prey species (Bettolli et al. 1992; Dibble et al. 1996). This nuisance species is already reducing the public's ability to use the reservoir for fishing and other recreational activities, and thus needs some level of control. Specific control measures are discussed in Hand et al. (2011).

Soldier's Meadow Reservoir

Historically, Soldier's Meadow Reservoir has had poor survival and recruitment of largemouth bass (predator species), and the number of fish collected in surveys remained low and steady. Over the last decade, this population has not seen appreciable spawning or recruitment, and attempts have been made to develop a population by stocking catchable size fish over 200 mm in length. However, as in previous surveys, few largemouth bass were collected in 2009. The presence of fish under 200 mm indicates that there is some successful reproduction occurring. However, this has been insufficient to establish a viable population. The rapid increase in black bullhead numbers and the introduction of yellow perch has likely resulted in a high level of predation on eggs and juvenile bass; thus, causing or contributing to recruitment failure (Leonard et al. 2010). Due to these problems, a major renovation of the lake is needed to eliminate unwanted species and restore the fishery. Options for restored fisheries include a standard two story fishery of warmwater species (largemouth bass and bluegill) and hatchery trout, or a trophy trout fishery.

Waha Lake

The annual survival rates (S) for smallmouth bass of 41.8% was much higher than those reported for populations in Little Goose Reservoir (28%; Rohrer 1984) and Brownlee Reservoir (28%; Bennett et al., 1983), but lower than the 54.4% and 50.3% seen in Dworshak Reservoir in 2004 and 2007 (Hand et al. 2011). The higher survival in Waha Lake and Dworshak Reservoir may be a function of cooler water temperatures and slower growth seen in these reservoirs, which have similar bathymetry. Cold water and slower growth often allows fish to grow older than they would in warmer waters where growth is fast (Adams and Breck 1990; King et al 1991). However, in contrast to Dworshak Reservoir, no smallmouth bass over 4 years were collected in Waha Lake. This indicates either a sampling bias, or a situation where smallmouth bass do not survive long in the reservoir due to harvest or other factors. No fish over 300 mm have been collected since 2001 (Schriever et al. 2008). As with Dworshak Reservoir, Waha Lake is very steep-sided. Thus, we may not be sampling larger fish which could be in deeper water. If we did not effectively sample the entire population of smallmouth bass, our catch curves would over-estimate mortality, making this information unreliable.

Creel surveys indicate that smallmouth bass harvest has increased from 1999 to 2005 (Hand 2009; Hand and Schriever 2009), with estimated catch increasing from 49 to 273. This level of harvest could also be contributing to the lack of larger fish in the reservoir.

MANAGEMENT RECOMMENDATIONS

1. Develop Lewiston levee ponds along the Snake River into put-and-take trout fisheries.

2. Stop largemouth bass transfers until we determine why these fish are not doing well in the reservoirs we are transferring them to.

3. Investigate the potential for moving to a fingerling only program in Deer Creek Reservoir.

4. Develop methodology to collect smallmouth bass in Dworshak Reservoir that are more representative of the population structure. Assess temporal differences in catch by sampling several times from mid-May through mid-June. Assess “deep cathode” technique.

5. Conduct lowland lake surveys of Moose Creek Reservoir, Spring Valley Reservoir, Winchester Lake, and Robinson Pond in 2010 to provide pre-treatment data for nuisance aquatic vegetation control study.

6. Investigate the potential for renovating Soldier’s Meadow Reservoir to provide a fishery most acceptable to the public.

7. Record fish lengths of all harvested fish encountered during next creel survey to determine if restrictive regulations are needed for any reservoirs.

Table 17. Results of impromptu creel surveys conducted on regional lowland lakes and reservoirs, 2009.

Water	Date	# Anglers	Total hours	Rainbow trout	Brook trout	Bluegill	Largemouth bass	Smallmouth bass	Pumpkin seed	Yellow perch	Black crappie	Total	Rainbow trout CPUE	Overall CPUE
Deer Creek Reservoir														
	5-May	2	4	6								6	1.50	1.50
	20-May	2	5	12								12	2.40	2.40
	31-May	28	37	84								84	2.27	2.27
	18-Jun	7	9	19								19	2.11	2.11
	21-Jun	10	14	24								24	1.71	1.71
	19-Jul	14	29	59								59	2.03	2.03
	19-Aug	16	28	45								45	1.61	1.61
	29-Aug	20	37	67								67	1.81	1.81
	12-Sep	6	14	20								20	1.43	1.43
	22-Sep	8	14	19								19	1.36	1.36
	subtotal	113	191	355	0	0	0	0	0	0	0	355	1.86	1.86
Elk Creek Reservoir														
	25-Apr	2	3	3								3	1.00	1.00
	5-May	7	7	2	6							8	0.29	1.14
	31-May	22	53	61	8	1		2				72	1.15	1.36
	18-Jun	9	8	9			1					10	1.13	1.25
	9-Jul	5	5	20		1						21	4.00	4.20
	21-Jun	9	22	18	2	3						23	0.82	1.05
	19-Jul	11	24	24	1	2		1				28	1.00	1.17
	19-Aug	6	4	2							2	4	0.50	1.00
	29-Aug	14	30	31	2	2						35	1.03	1.17
	12-Sep	7	16	17								17	1.06	1.06
	22-Sep	4	12	14	3							17	1.17	1.42
	subtotal	96	184	201	22	9	1	3	0	0	2	238	1.09	1.29
Mann Lake														
	25-Apr	10	13	11		1					57	69	0.85	5.31
	5-May	15	22	14					2		174	190	0.64	8.64
	31-May	23	31	37		2			7		62	108	1.19	3.48
	18-Jun	5	5	3								3	0.60	0.60
	21-Jun	11	13	15		2	3		3		17	40	1.15	3.08
	9-Jul	10	16	16		7						23	1.00	1.44
	19-Jul	4	6	9								9	1.50	1.50
	19-Aug	8	18	22		4	8		6		2	42	1.22	2.33
	29-Aug	18	34	29		6	4		8		4	51	0.85	1.50
	12-Sep	4	9	12					2			14	1.33	1.56
	22-Sep	7	16	20			10		3		1	34	1.25	2.13
	subtotal	115	183	188	0	22	25	0	31	0	317	583	1.03	3.19
Moose Creek Reservoir														
	25-Apr	9	5	10							2	12	2.00	2.40
	5-May	7	11	22		5						27	2.00	2.45
	18-May	1	0.5			2						2	0.00	4.00
	31-May	33	87	118		27	3				3	151	1.36	1.74
	18-Jun	7	12	12		4	8					24	1.00	2.00
	21-Jun	15	25	37		4	4					45	1.48	1.80
	9-Jul	7	31	10		61					1	72	0.32	2.32
	19-Jul	10	18	8		47	1				2	58	0.44	3.22
	19-Aug	8	16	14		10	1					25	0.88	1.56
	29-Aug	22	62	80		35	2					117	1.29	1.89
	12-Sep	9	24	21		36					2	59	0.88	2.46
	22-Sep	6	8	10		5	1					16	1.25	2.00
	subtotal	134	299.5	342	0	236	20	0	0	0	10	608	1.14	2.03

Table 17 (con). Results of impromptu creel surveys conducted on regional lowland lakes and reservoirs, 2009.

Water	Date	# Anglers	Total hours	Rainbow trout	Brook trout	Bluegill	Largemouth bass	Smallmouth bass	Pumpkin seed	Yellow perch	Black crappie	Total	Rainbow trout CPUE	CPUE
Soldier's Meadow Reservoir														
	25-Apr	1	2	3								3	1.50	1.50
	5-May	2	4	3								3	0.75	0.75
	31-May	9	27	23								23	0.85	0.85
	18-Jun	2	3	2								2	0.67	0.67
	21-Jun	5	9	8								8	0.89	0.89
	19-Jul	12	16	11							4	15	0.69	0.94
	19-Aug	6	17	18								18	1.06	1.06
	29-Aug	10	30	22								22	0.73	0.73
	12-Sep	3	15	9							4	13	0.60	0.87
	22-Sep	0												
	subtotal	50	123	99	0	0	0	0	0	0	8	107	0.80	0.87
Spring Valley Reservoir														
	25-Apr	34	63	76		14	2					92	1.21	1.46
	5-May	4	6	7			3					10	1.17	1.67
	31-May	27	38	45		17	5				18	85	1.18	2.24
	18-Jun	7	6	11								11	1.83	1.83
	16-Jun	1	2			10						10	0.00	5.00
	21-Jun	15	19	15		7	9				14	45	0.79	2.37
	9-Jul	2	3	8								8	2.67	2.67
	19-Jul	12	20	27		13	1					41	1.35	2.05
	19-Aug	8	10	14		17						31	1.40	3.10
	29-Aug	36	88	77		35	10				12	134	0.88	1.52
	12-Sep	9	14	20		17	2					39	1.43	2.79
	22-Sep	3	6	7		4						11	1.17	1.83
	subtotal	124	212	231	0	120	30	0	0	0	44	517	1.09	2.44
Waha Lake														
	25-Apr	2	4	5								5	1.25	1.25
	5-May	1	2	16								16	8.00	8.00
	31-May	3	10	27								27	2.70	2.70
	18-Jun	0												
	21-Jun	3	3	6								6	2.00	2.00
	19-Jul	5	5	12								12	2.40	2.40
	19-Aug	0												
	29-Aug	3	9	11								11	1.22	1.22
	12-Sep	1	4	5								5	1.25	1.25
	22-Sep	0												
	subtotal	18	37	82	0	0	0	0	0	0	0	82	2.22	2.22
Winchester Lake														
	25-Apr	39	79	118		10	19			4		151	1.49	1.91
	5-May	10	34	29		34	5			7		75	0.85	2.21
	31-May	69	149	183		77	15			6	16	297	1.23	1.99
	18-Jun	14	30	24		21	4					49	0.80	1.63
	21-Jun	72	157	93		54	11			2	1	161	0.59	1.03
	19-Jul	15	39	27		44	6			34	21	132	0.69	3.38
	19-Aug	16	44	30		62	4				4	100	0.68	2.27
	29-Aug	67	178	228		63	10			27	8	336	1.28	1.89
	12-Sep	10	40	46		21	2			14		83	1.15	2.08
	22-Sep	10	30	34		18	6			11	4	73	1.13	2.43
	subtotal	322	780	812	0	404	82	0	0	105	54	1457	1.04	1.87
Season Totals		**972**	**2009.5**	**2310**	**22**	**791**	**158**	**3**	**31**	**105**	**435**	**3947**	**1.15**	**1.96**

Table 18. Back-calculated length (mm) at annuli of smallmouth bass collected from Dworshak Reservior, Idaho, in 2009.

Age Group	Number Aged	1	2	3	4	5	6	7
1	0							
2	8	78	138					
3	30	81	125	172				
4	15	75	121	168	216			
5	7	74	107	151	184	234		
6	3	72	117	159	197	230	271	
7	2	88	126	171	215	265	311	360
Avg. Length		78	122	164	203	243	291	360
N =	**76**							
Annual growth		44	42	39	40	49	69	

Table 19. Age-length (mm) key for smallmouth bass collected from Dworshak Reservoir, Idaho, in 2009.

Length	Number in sample	Age 1	2	3	4	5	6	7
100	0							
110	2		2					
120	0							
130	5			5				
140	6			3	3			
150	19		4	11	4			
160	16		8	8				
170	7			7				
180	14			11	3			
190	14			14				
200	27		5	18	4			
210	30			30				
220	22			11		11		
230	21		3	9	9			
240	24			4	8	12		
250	23			6	12	5		
260	11						11	
270	9			2	2	3	2	
280	7				4	3		
290	3				3			
300	2			1	1			
310	0							
320	0							
330	1						1	
340	0							1
350	0							
360	0							
370	0							
380	0							
390	0							
400	0							
410	0							
420	0							
430	0							1
440	0							
450	0							
Total	263	0	22	140	53	34	14	2

Table 20. Back-calculated length (mm) at annuli of smallmouth bass collected from Elk Creek Reservoir, Idaho, in 2005 and 2009.

2005

Age Group	Number Aged	1	2	3	4	5	6
1	1	91					
2	4	52	135				
3	4	66	131	207			
4	2	62	119	176	252		
5	5	55	114	182	265	332	
6	1	56	138	184	262	341	425
Avg. Length		64	128	187	259	337	425
N =	**17**						
Annual growth		64	60	72	77	88	

2009

Age Group	Number Aged	1	2	3	4	5	6	7	8
1	3	82							
2	1	108	156						
3	4	81	135	199					
4	5	88	124	165	210				
5	5	70	119	174	209	252			
6	1	66	116	144	174	204	220		
7	1	122	179	278	321	363	393	418	
8	2	96	162	218	254	280	330	370	413
Avg. Length		89	141	196	234	275	315	394	413
N =	**22**								
Annual growth		52	55	37	41	40	79		

Table 21. Back-calculated length (mm) at annuli of largemouth bass collected from Elk Creek Reservoir, Idaho, in 2005 and 2009.

2005

Age Group	Number Aged	1	2	3	4	5	6
1	0						
2	0						
3	1	66	115	151			
4	4	65	133	192	256		
5	0						
6	1	69	140	235	287	374	443
Avg. Length		67	130	193	272	374	443
N =	**6**						
Annual growth		63	63	79	102	69	

2009

Age Group	Number Aged	1	2	3	4	5	6	7
1								
2	3	79	175					
3	3	80	150	244				
4	4	88	160	220	280			
5	12	89	155	213	261	312		
6	2	80	130	180	239	282	309	
7	2	80	125	187	275	338	389	426
Avg. Length		83	149	209	264	311	349	426
N =	**26**							
Annual growth		67	60	55	47	38	77	

Table 22. Back-calculated length (mm) at annuli of pumpkinseed collected from Elk Creek Reservoir, Idaho, in 2009.

Age Group	Number Aged	1	2	3	4	5
1	4	41				
2	13	39	63			
3	9	43	68	90		
4	7	48	73	100	120	
5	12	44	65	90	110	124
Avg. Length		43	67	93	115	124
N =	**45**					
Annual growth			24	26	22	9

Table 23. Back-calculated length (mm) at annuli of black crappie collected from Elk Creek Reservoir, Idaho, in 2009.

Age Group	Number Aged	1	2	3	4	5	6	7
1	9	55						
2	4	47	93					
3	3	49	81	120				
4	2	65	104	138	166			
5	15	55	91	132	156	179		
6	1	46	63	95	138	157	183	
7	2	55	84	130	162	176	190	212
Avg. Length		53	86	123	155	171	186	212
N =	**36**							
Annual growth			33	37	32	15	15	25

Table 24. Back-calculated length (mm) at annuli of largemouth bass collected from Moose Creek Reservoir, Idaho, in 2004 and 2009.

2004

Age Group	Number Aged	1	2	3	4	5
1	7	70				
2	2	75	129			
3	3	66	116	159		
4	1	75	114	153	214	
5	1	76	141	229	284	348
Avg. Length		72	125	180	249	348
N =	**14**					
Annual growth		53	55	69	99	

2009

Age Group	Number Aged	1	2	3	4	5	6	7	8	9	10
1											
2	21	77	144								
3	1	64	129	196							
4	8	74	128	177	214						
5	10	74	127	167	192	235					
6	4	80	138	184	220	251	308				
7	1	71	114	155	187	230	281	322			
8	3	80	120	182	232	283	326	379	421		
9	3	69	101	150	200	244	280	327	379	409	
10	1	74	129	173	243	287	324	405	434	464	492
Avg. Length		74	126	173	213	255	304	358	411	436	492
N =	**52**										
Annual growth		52	47	40	42	49	54	53	25	55	

Table 25. Back-calculated length (mm) at annuli of bluegill collected from Moose Creek Reservoir, Idaho, in 2004.

Age Group	Number Aged	1	2	3
1	1	34		
2	14	38	85	
3	9	49	95	142
Avg. Length		40	90	142
N =	**24**			
Annual growth		50	52	

Table 26. Back-calculated length (mm) at annuli of black crappie collected from Moose Creek Reservoir, Idaho, in 2004 and 2009.

2004

Age Group	Number Aged	1	2	3	4	5
1	0					
2	0					
3	2	61	103	121		
4	20	45	89	137	171	
5	2	40	67	107	154	194
Avg. Length		49	86	122	162	194
N =	**24**					
Annual growth		37	36	40	32	

2009

Age Group	Number Aged	1	2	3	4	5	6	7	8
1	0								
2	0								
3	1	70	122	168					
4	5	56	98	145	179				
5	6	57	93	131	166	190			
6	5	54	91	129	156	177	194		
7	0								
8	2	49	86	123	154	172	187	198	208
Avg. Length		57	98	139	164	180	191	198	208
N =	**19**								
Annual growth		41	41	25	16	11	7	11	

Table 27. Back-calculated length (mm) at annuli of pumpkinseed collected from Moose Creek Reservoir, Idaho, in 2009.

Age Group	Number Aged	1	2	3	4	5	6
1	0						
2	0						
3	5	42	65	93			
4	3	48	77	109	129		
5	2	47	57	73	95	117	
6	5	40	60	83	104	119	129
Avg. Length		44	65	90	109	118	129
N =	**15**						
Annual growth		21	25	20	9	11	

Table 28. Back-calculated length (mm) at annuli of yellow perch collected from Solder's Meadow Reservoir, Idaho, in 2009.

Age Group	Number Aged	1	2	3	4
1	12	61			
2	12	75	107		
3	6	64	103	134	
4	2	58	88	102	138
Avg. Length		64	100	118	138
N =	**32**				
Annual growth		35	18	20	

Table 29. Age-length (mm) key for yellow perch collected from Soldier's Meadow Reservoir, Idaho, in 2009.

	Number in	Age			
Length	sample	1	2	3	4
50		1			
60	20	20			
70	4	4			
80	0				
90	0				
100	0				
110	5	3	2		
120	31	7	18	6	
130	17		13	4	
140	2		2		
150	13		7		6
160	19		4	15	
170	8			4	4
180	1				1
190	2				2
200	0				
Total	43	35	46	29	13

Table 30. Back-calculated length (mm) at annuli of black crappie collected from Solder's Meadow Reservoir, Idaho, in 2005 and 2009.

2005

Age Group	Number Aged	1	2	3	4	5	6
1	0						
2	1	52	115				
3	2	62	102	128			
4	4	86	128	159	186		
5	8	67	102	133	168	190	
6	4	65	98	130	163	187	208
Avg. Length		66	109	137	172	189	208
N =	**19**						
Annual growth		43	29	35	17	19	

2009

Age Group	Number Aged	1	2	3	4	5
1	0					
2	2	94	135			
3	1	80	117	161		
4	2	77	100	142	161	
5	3	69	111	141	163	182
Avg. Length		80	116	148	162	182
N =	**8**					
Annual growth		36	32	14	20	

Table 31. Back-calculated length (mm) at annuli of largemouth bass collected from Solder's Meadow Reservoir, Idaho, in 2009.

Age Group	Number Aged	1	2	3	4	5	6
1	0						
2	0						
3	0						
4	3	63	96	127	149		
5	1	65	95	150	175	228	
6	1	75	122	137	149	176	230
Avg. Length		68	104	138	158	202	230
N =	**5**						
Annual growth		37	34	20	44	28	

Table 32. Back-calculated length (mm) at annuli of smallmouth bass collected from Waha Lake Idaho, in 2003 and 2004.

2003

Age Group	Number Aged	1	2	3	4
1	9	75			
2	12	90	141		
3	7	87	151	205	
4	2	85	123	162	194
Avg. Length		84	138	184	194
N =	**30**				
Annual growth		54	45	10	

2004

Age Group	Number Aged	1	2	3
1	3	82		
2	3	68	114	
3	4	82	138	203
Avg. Length		77	126	203
N =	**10**			
Annual growth		49	78	

Table 33. Age-length (mm) key for smallmouth bass collected from Waha Lake, Idaho, in 2003.

Length	Number in sample	Age 1	2	3	4
50	3	3			
60	14	14			
70	6	6			
80	0				
90	0				
100	3	1	2		
110	2		2		
120	2	2			
130	0				
140	2	1	1		
150	4	2	2		
160	1		1		
170	0				
180	0				
190	2		2		
200	0				
210	5		1	3	1
220	3		1	2	
230	3		1	1	1
240	0				
250	1			1	
260	1		1		
Total	52	29	14	7	2

Table 34. Population estimates and 95% confidence limits (CI) for largemouth bass collected in Moose Creek Reservoir, Idaho, in May, 2009.

All Fish

Sample	Number of fish captured			Total # of marked fish released	
Date	# marked R	# unmarked	Total - C	prior to sample period - M	C x M
5/14/2009	0	99	99	0	0
5/19/2009	13	104	117	99	11,583
5/21/2009	36	116	152	203	30,856
5/26/2009	43	73	116	319	37,004
5/28/2009	43	62	105	392	41,160
Total	135				120,603
Pop Est	**893**				
95% CI	764	1,075			

Fish >= 300 mm

Sample	Number of fish captured			Total # of marked fish released	
Date	# marked R	# unmarked	Total - C	prior to sample period - M	C x M
1	0	20	20	0	0
2	4	25	29	20	580
3	8	22	30	45	1,350
4	8	17	25	67	1,675
5	9	15	24	84	2,016
Total	29				5,621
Pop Est	**194**				
95% CI	142	305			

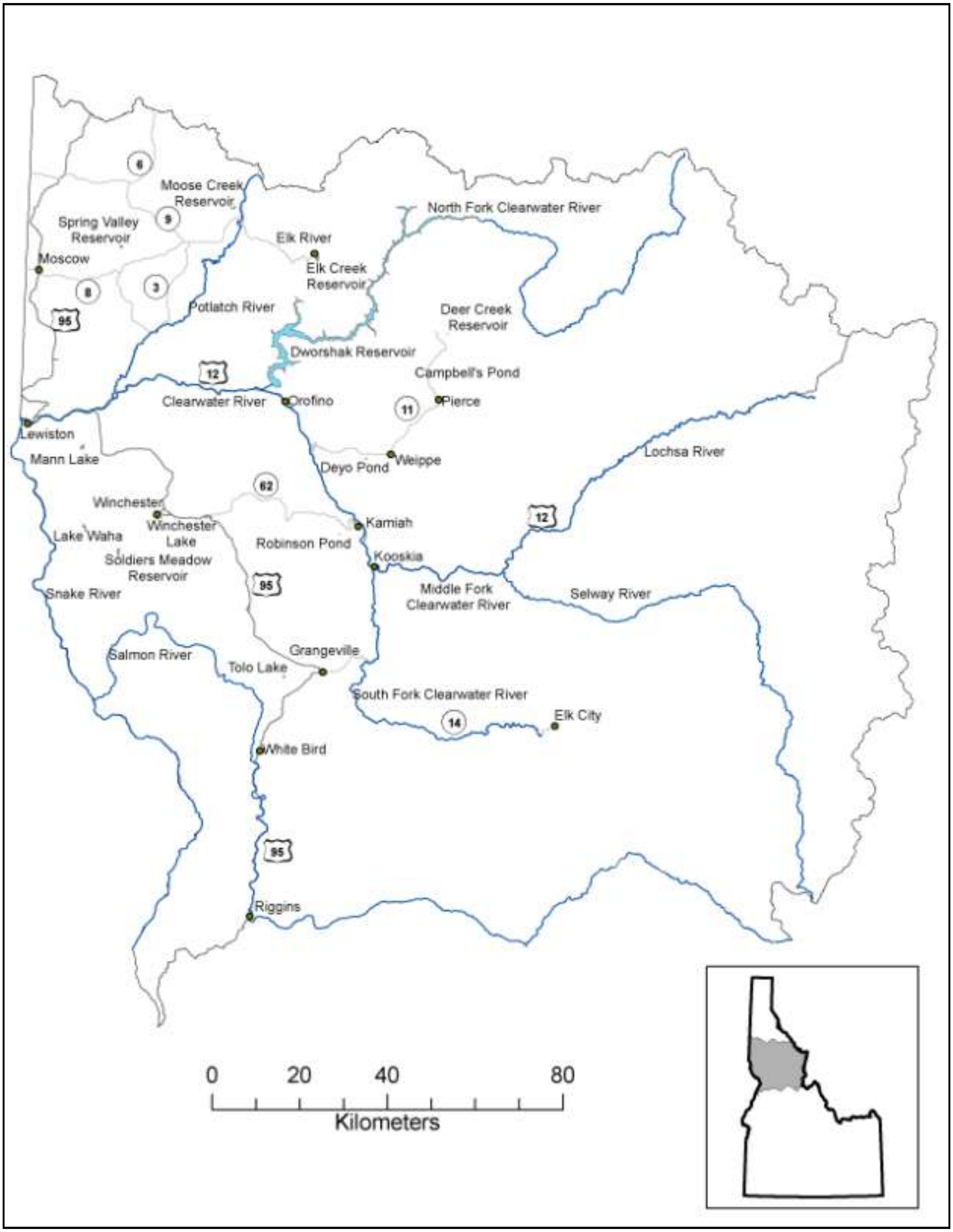


Figure 21. Map of lowland lakes and reservoirs in the Clearwater Region, Idaho.

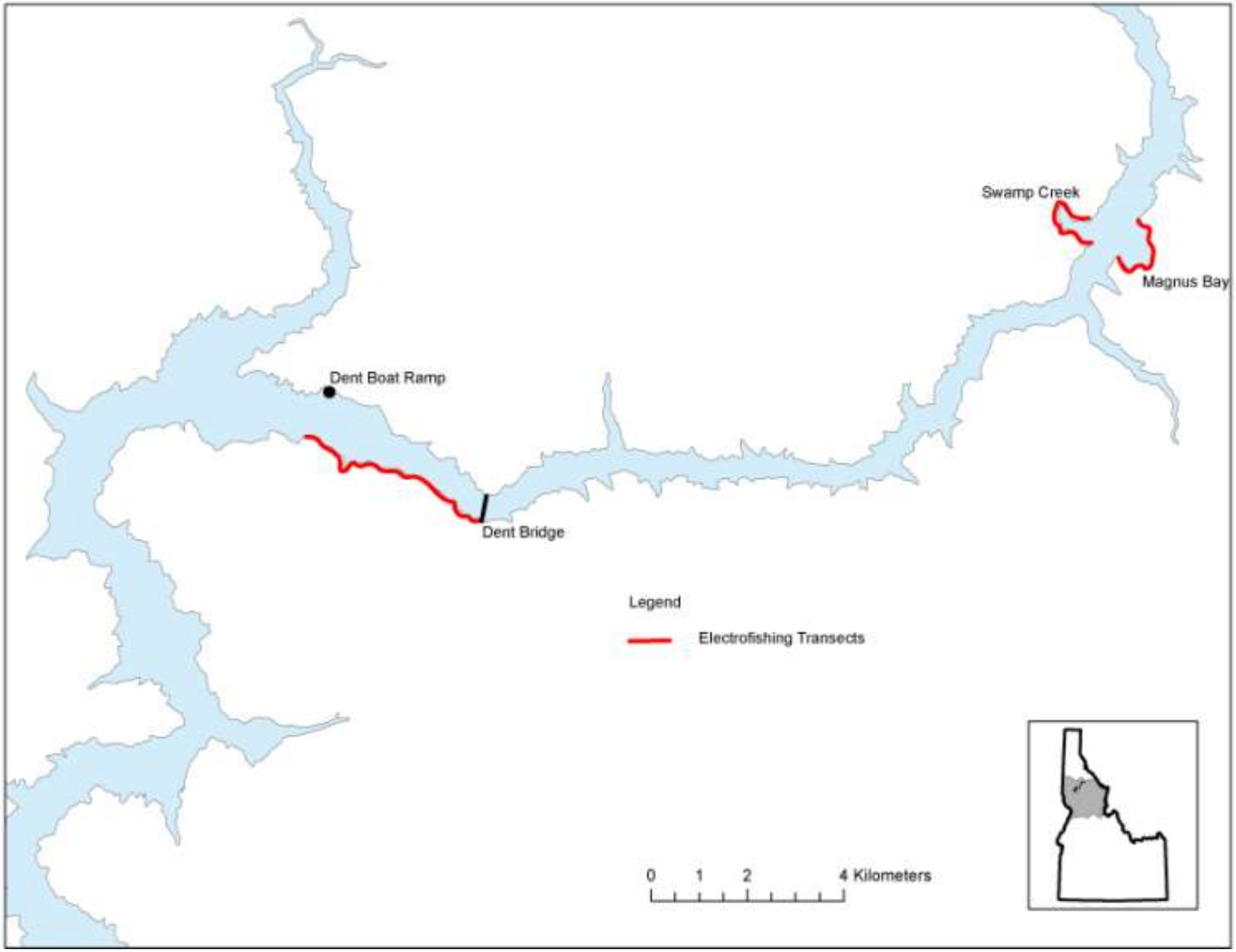


Figure 22. Map of smallmouth bass survey locations on Dworshak Reservoir in the Clearwater Region, Idaho.

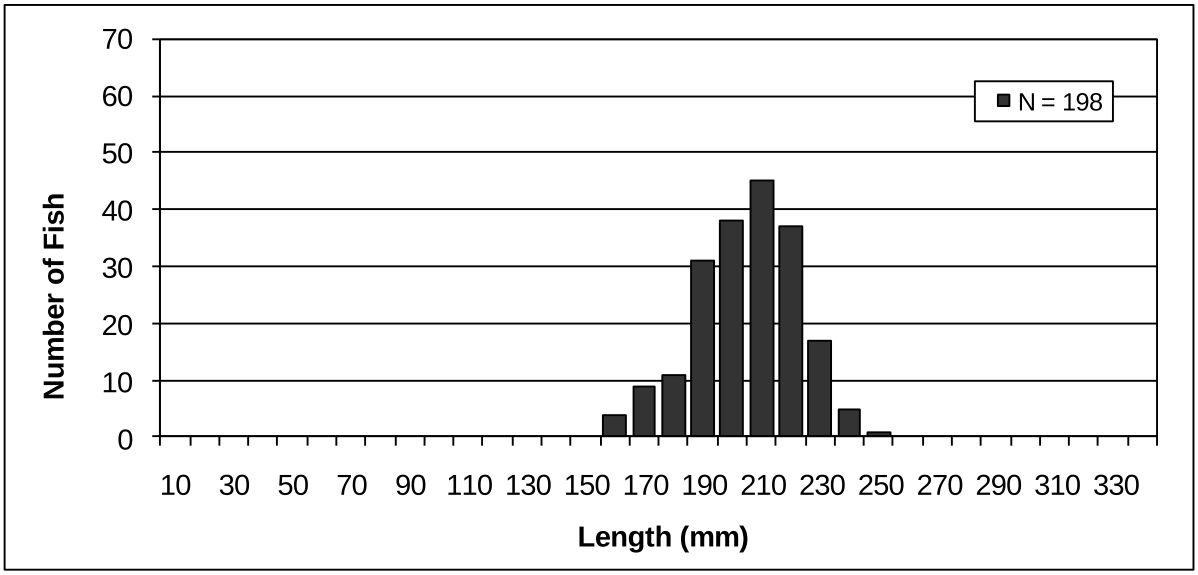


Figure 23. Length frequency distribution of largemouth bass transferred from Winchester Lake, Idaho, to Soldier's Meadow Reservoir, Idaho, in 2009.

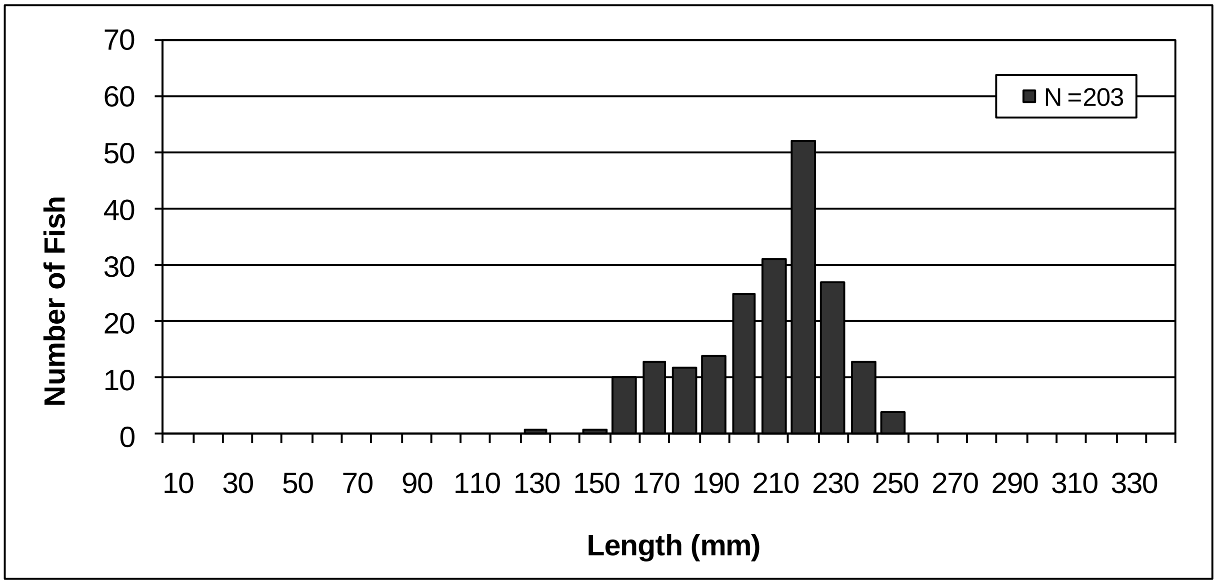
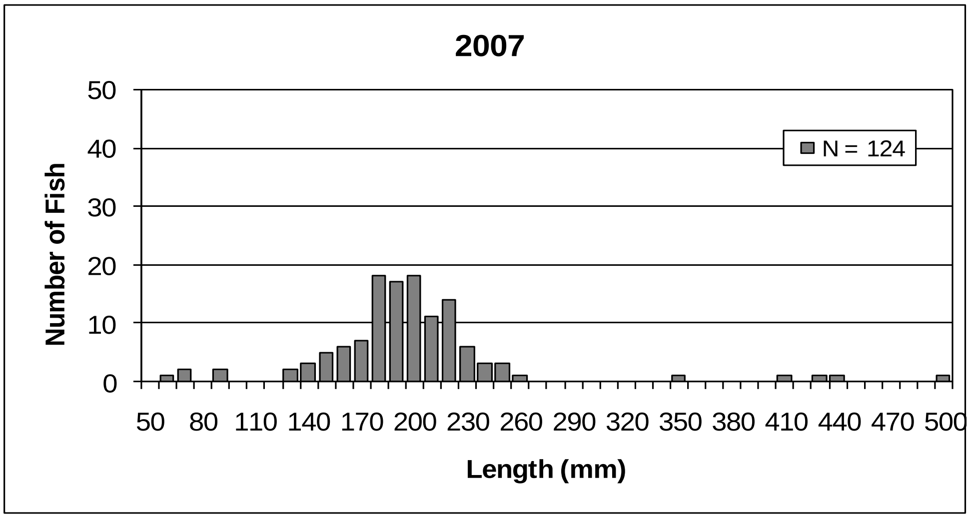
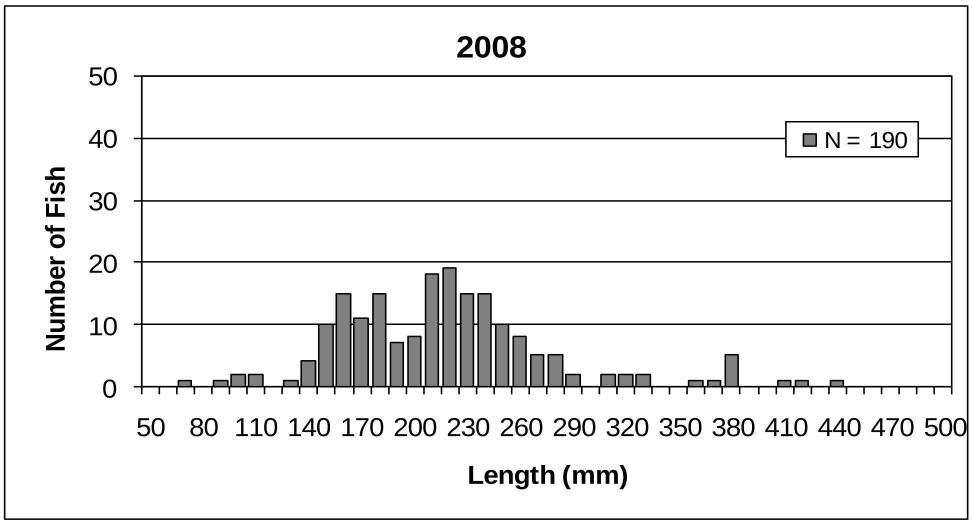


Figure 24. Length frequency distribution of largemouth bass transferred from Winchester Lake, Idaho, to Tolo Lake, Idaho, in 2009.





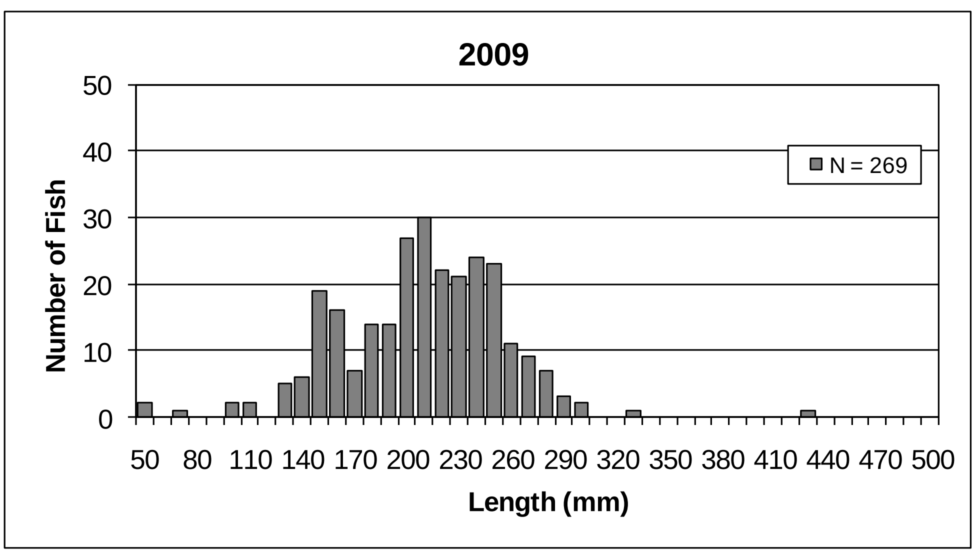


Figure 25. Length frequency distributions of smallmouth bass collected from standard surveys of Dworshak Reservoir, Idaho, in 2007 - 2009.

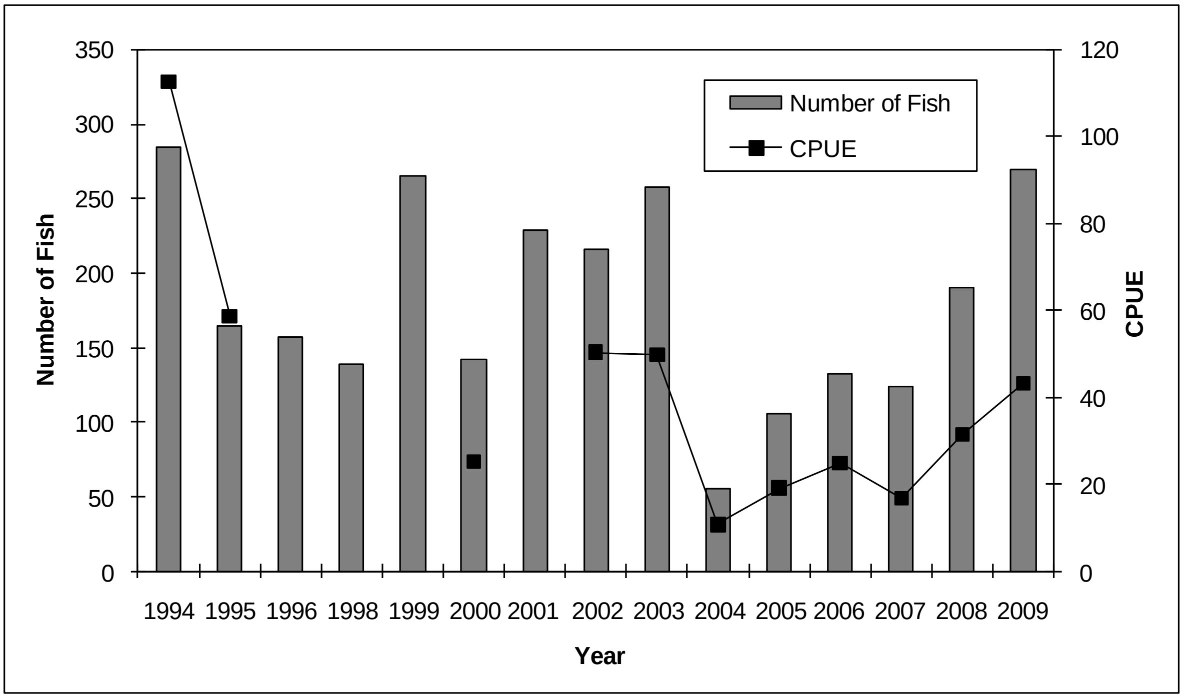


Figure 26. Number and catch per unit effort (CPUE; fish/hr) of smallmouth bass collected during annual population surveys of Dworshak Reservoir, Idaho, from 1994 - 2009.

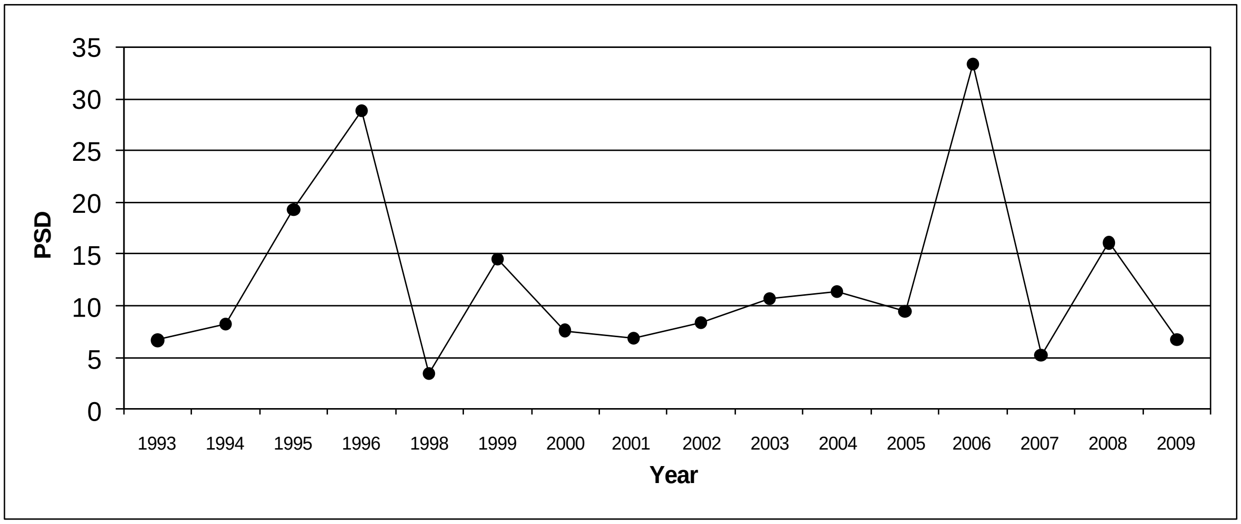


Figure 27. Proportional stock density (PSD) values of smallmouth bass collected during annual population surveys of Dworshak Reservoir, Idaho, from 1993 - 2009.

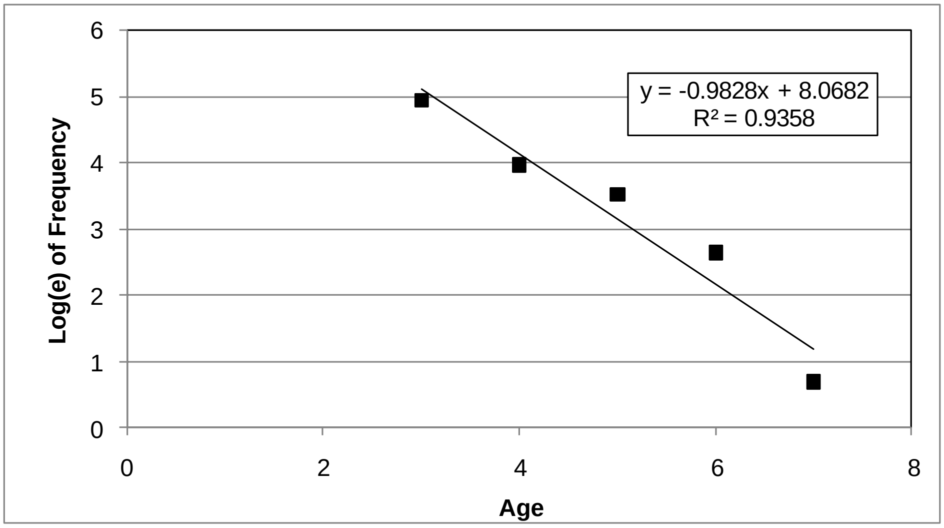


Figure 28. Catch curve for estimating annual mortality of smallmouth bass collected in Dworshak Reservoir, Idaho, in 2009.

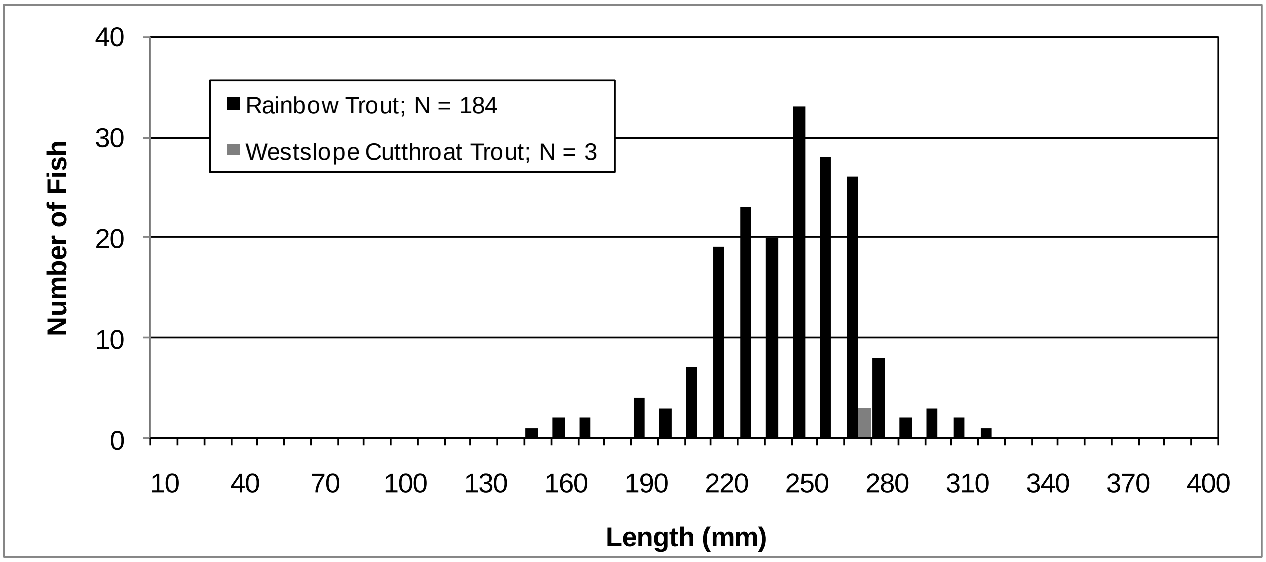


Figure 29. Length frequency distribution of rainbow trout and westslope cutthroat trout collected in Deer Creek Reservoir, Idaho, in 2009.

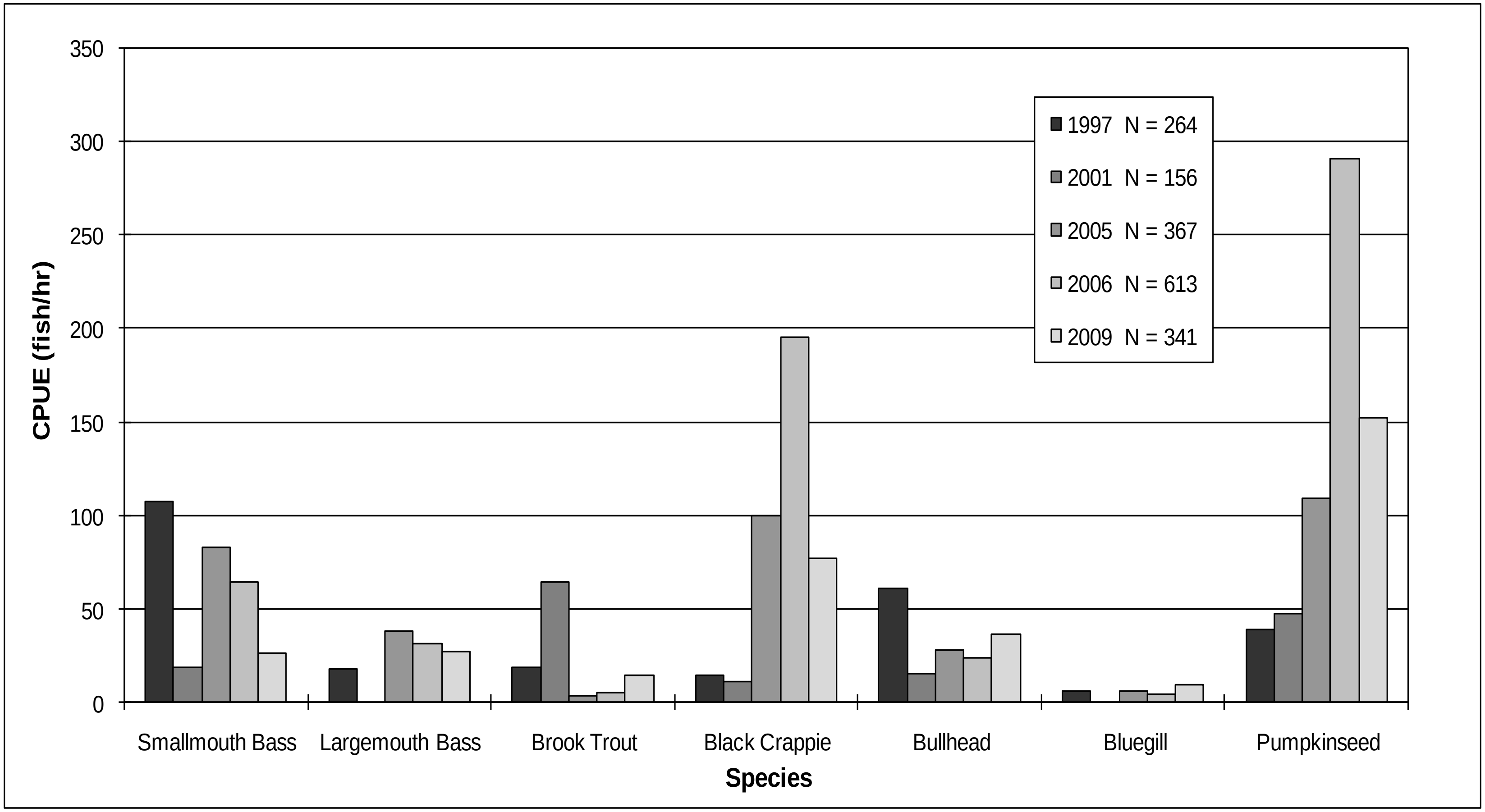
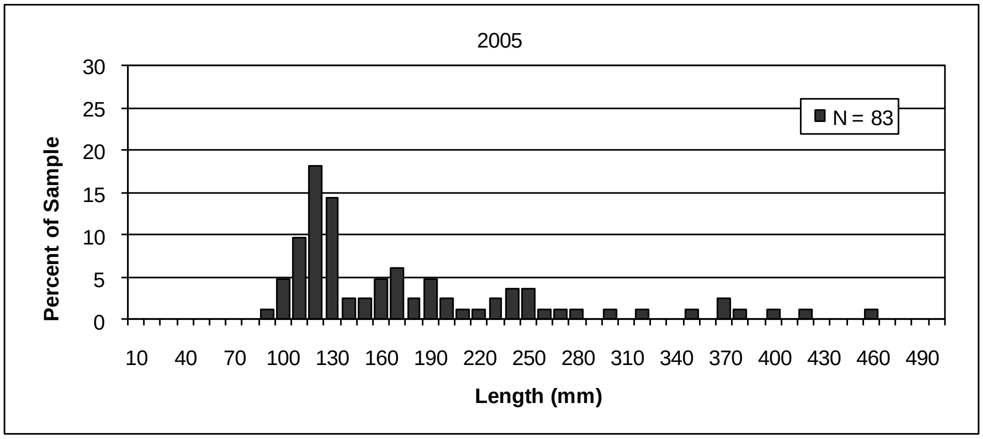
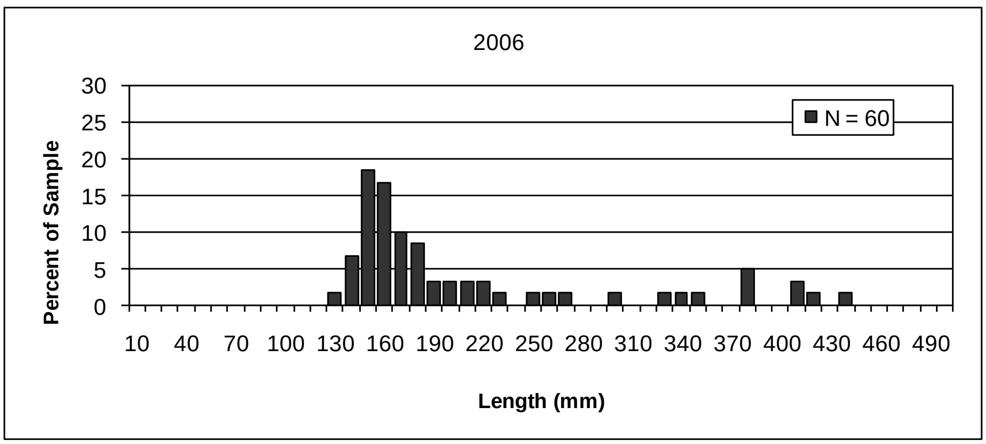


Figure 30. Catch per unit effort (CPUE; fish/hr) of fish collected from standard lake surveys of Elk Creek Reservoir, Idaho, from 1997 - 2009.





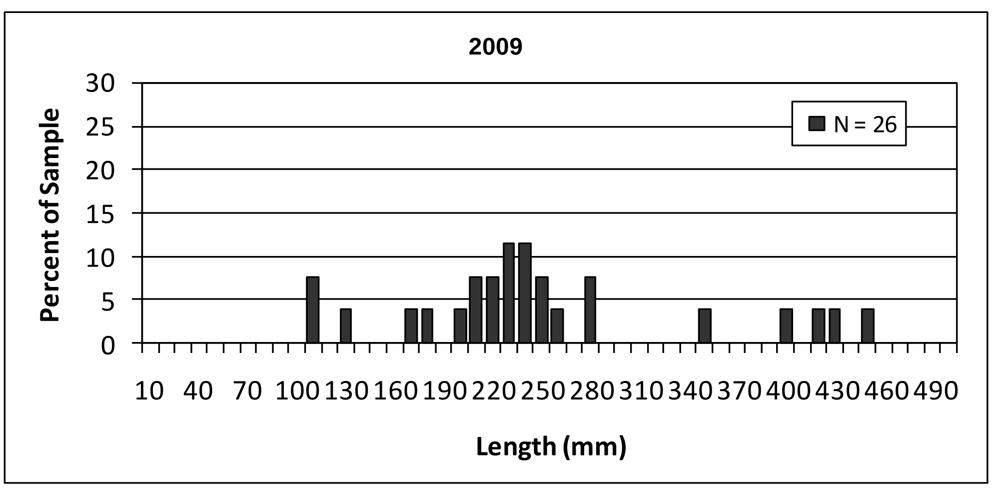
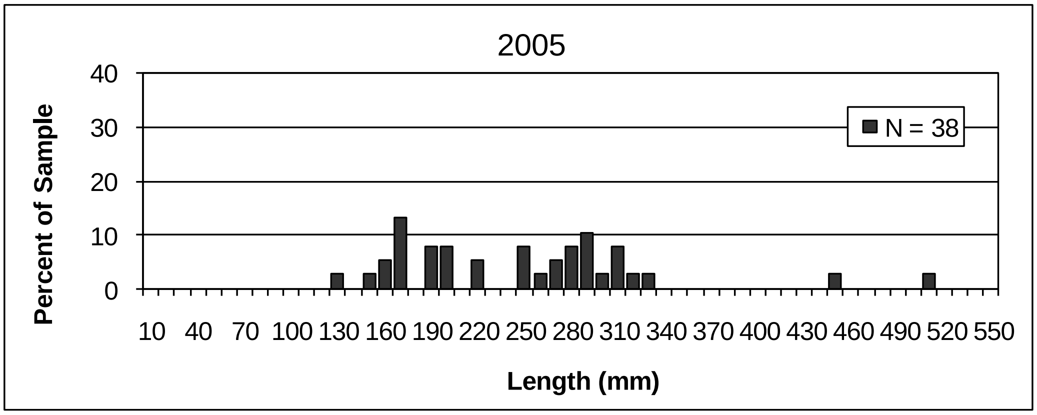
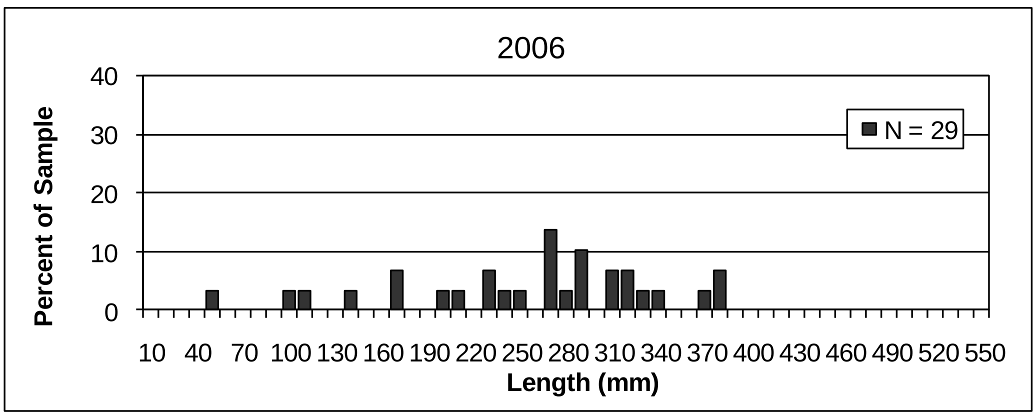


Figure 31. Length frequency distributions of smallmouth bass collected from standard lake surveys of Elk Creek Reservoir, Idaho, in 2005, 2006, and 2009.





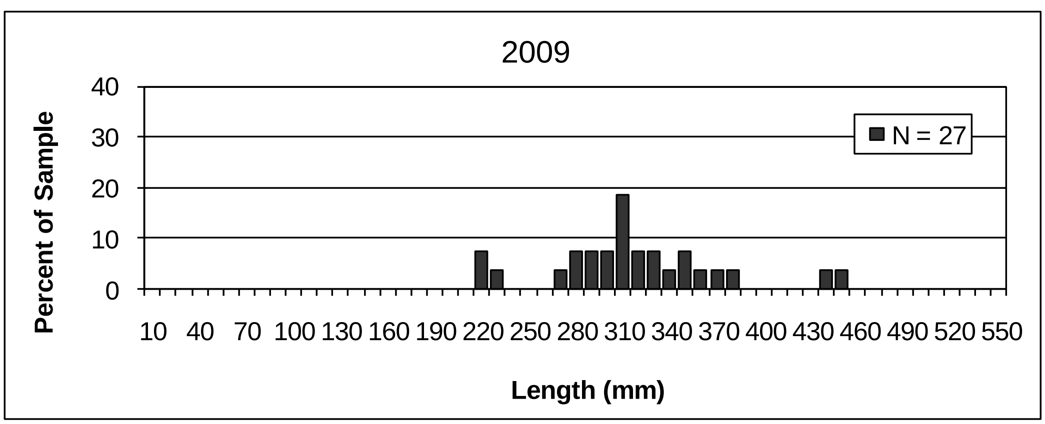


Figure 32. Length frequency distributions of largemouth bass collected from standard lake surveys of Elk Creek Reservoir, Idaho, in 2005, 2006, and 2009.

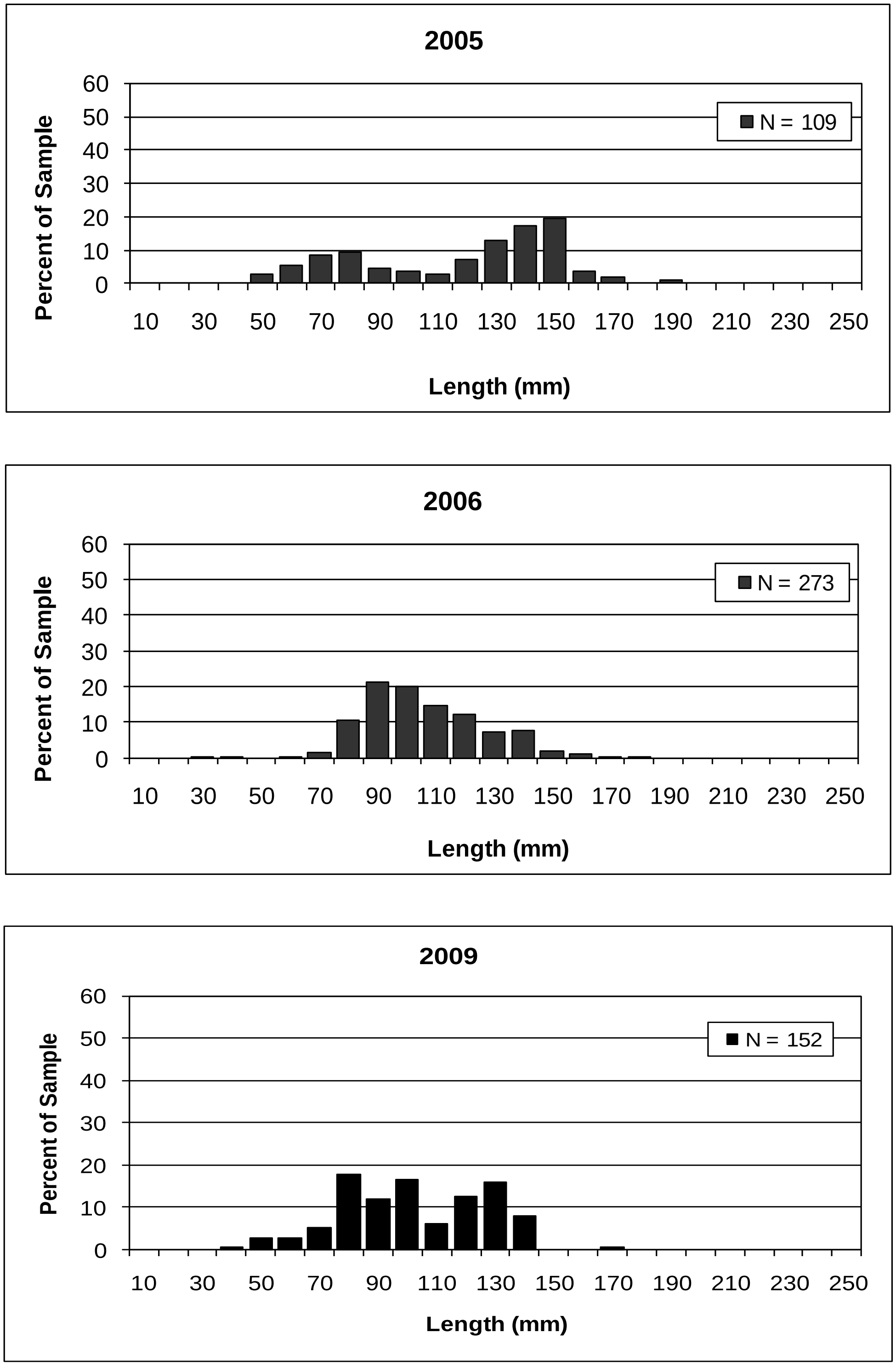


Figure 33. Length frequency distributions of pumpkinseed collected from standard lake surveys of Elk Creek Reservoir, Idaho, in 2005, 2006, and 2009.

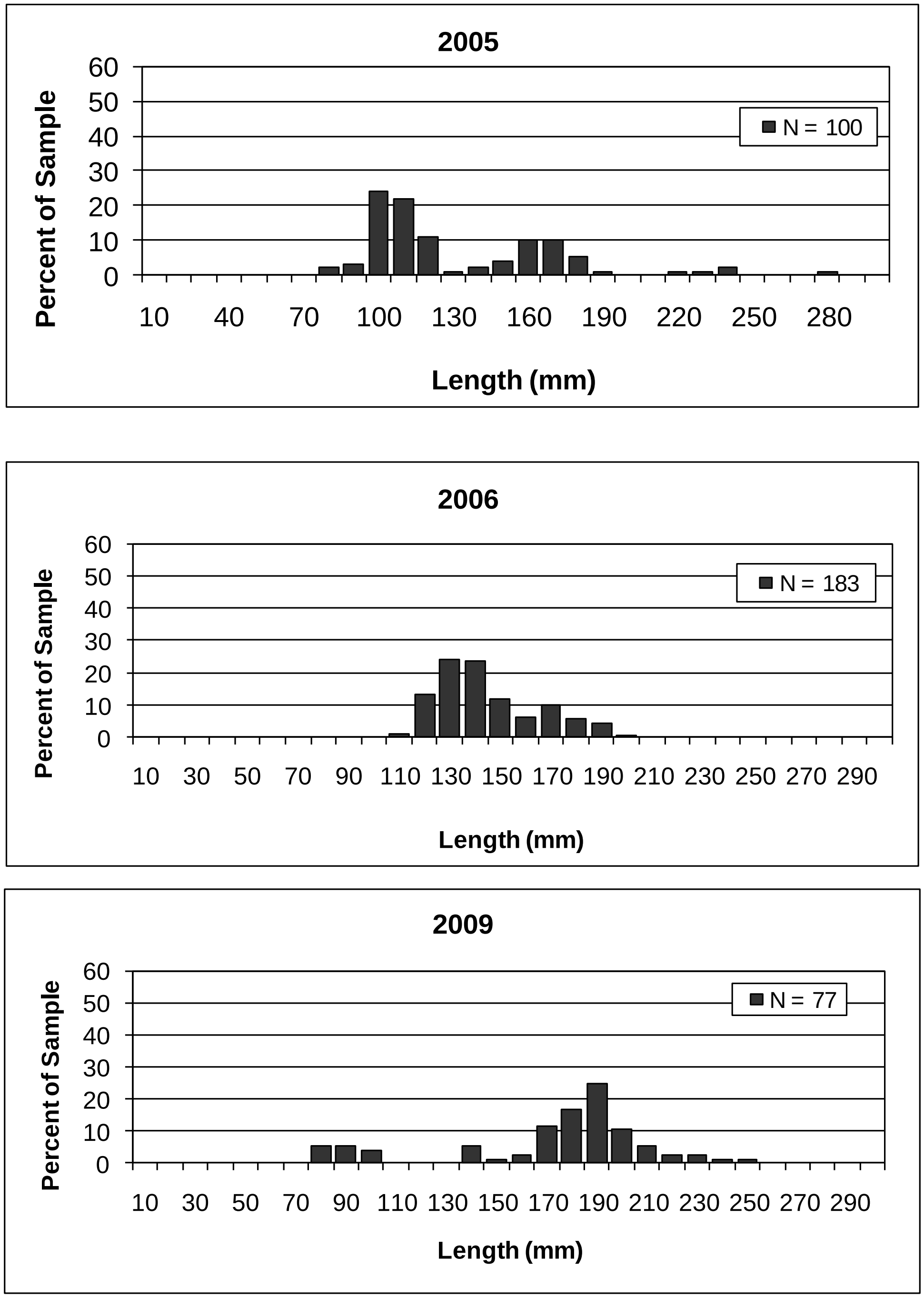


Figure 34. Length frequency distributions of black crappie collected from standard lake surveys of Elk Creek Reservoir, Idaho, in 2005, 2006, and 2009.

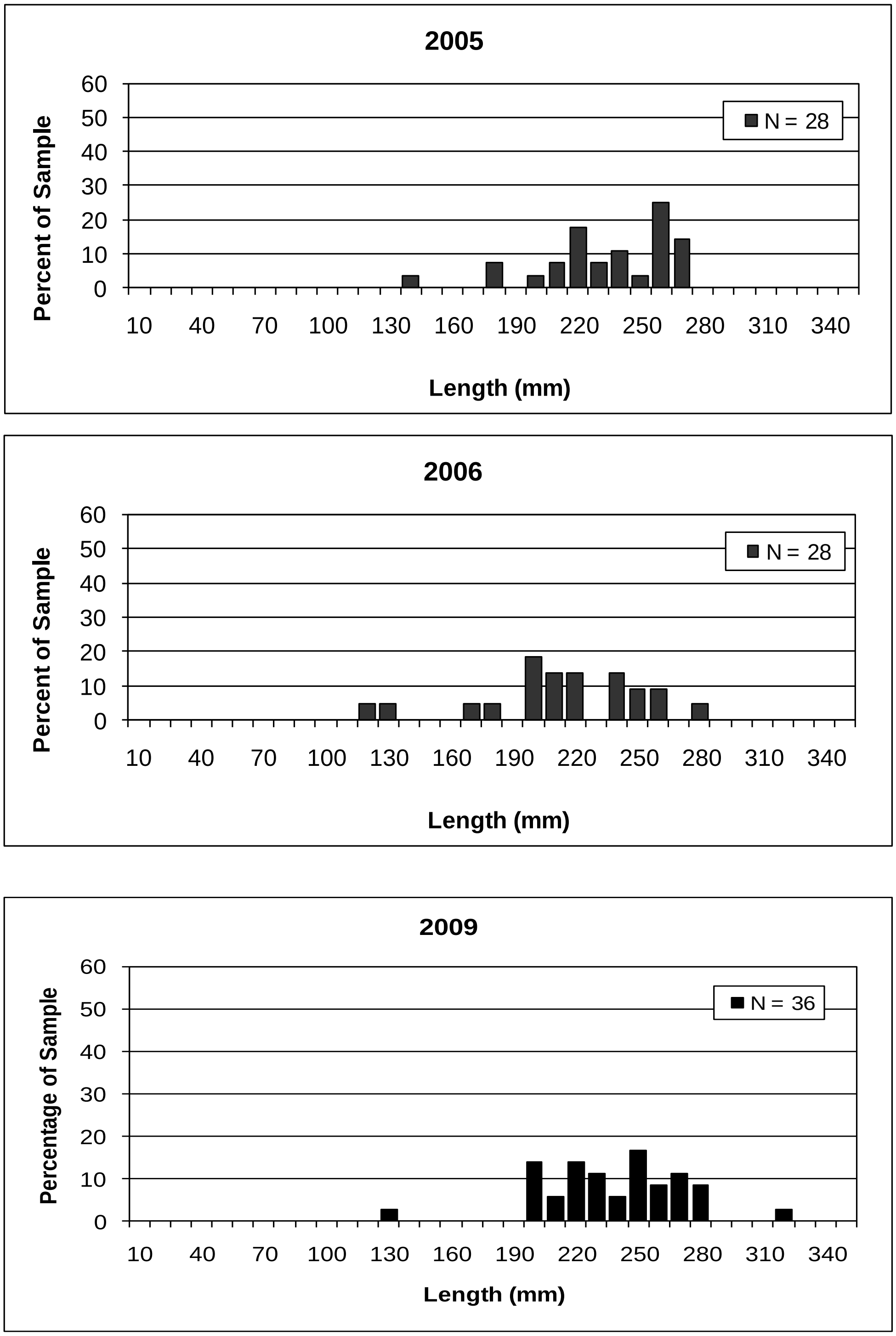


Figure 35. Length frequency distributions of brown bullhead collected from standard lake surveys of Elk Creek Reservoir, Idaho, in 1997, 2001, 2005, 2006, and 2009.

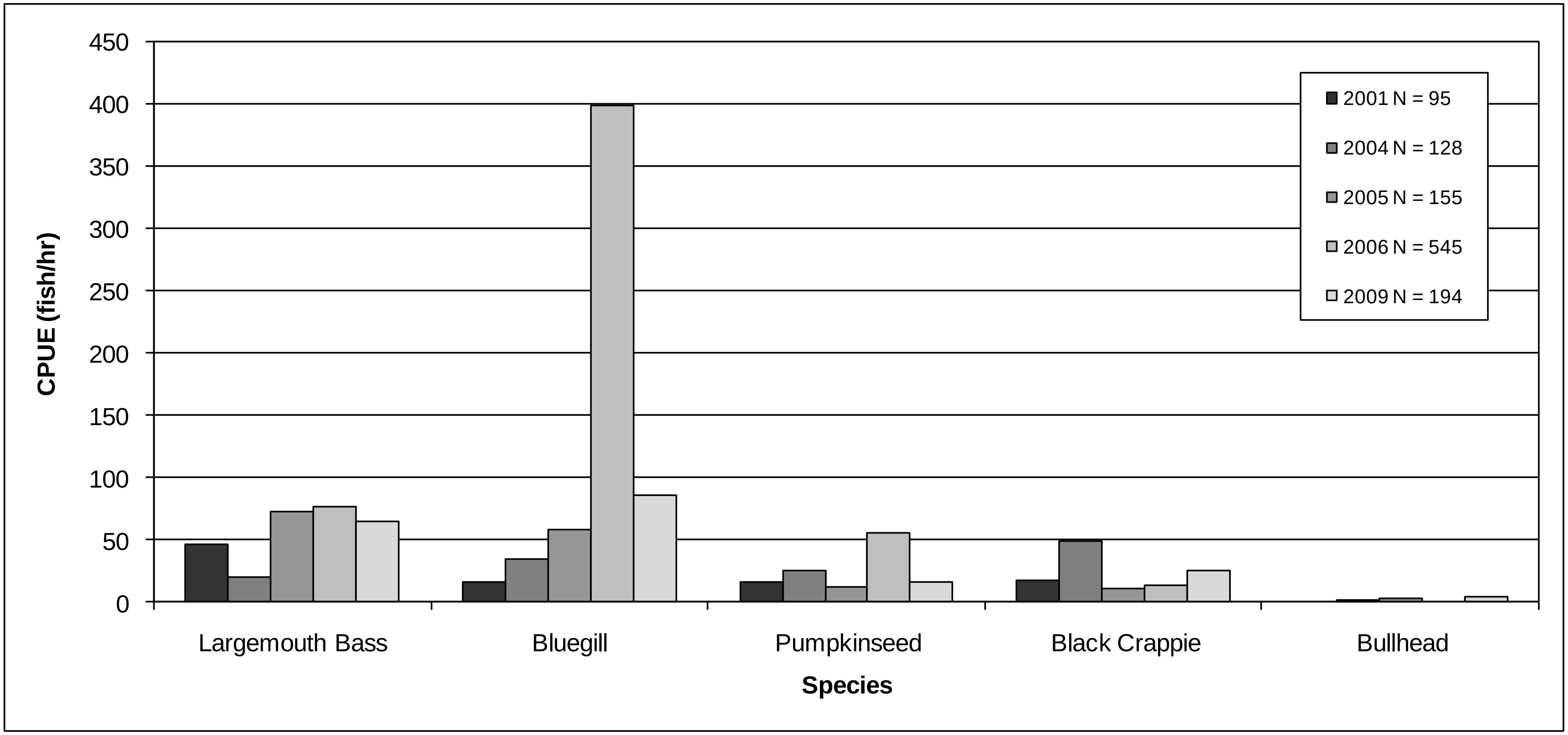


Figure 36. Catch per unit effort (CPUE; fish/hr) of fish collected from standard lake surveys of Moose Creek Reservoir, Idaho, from 2001 - 2009.

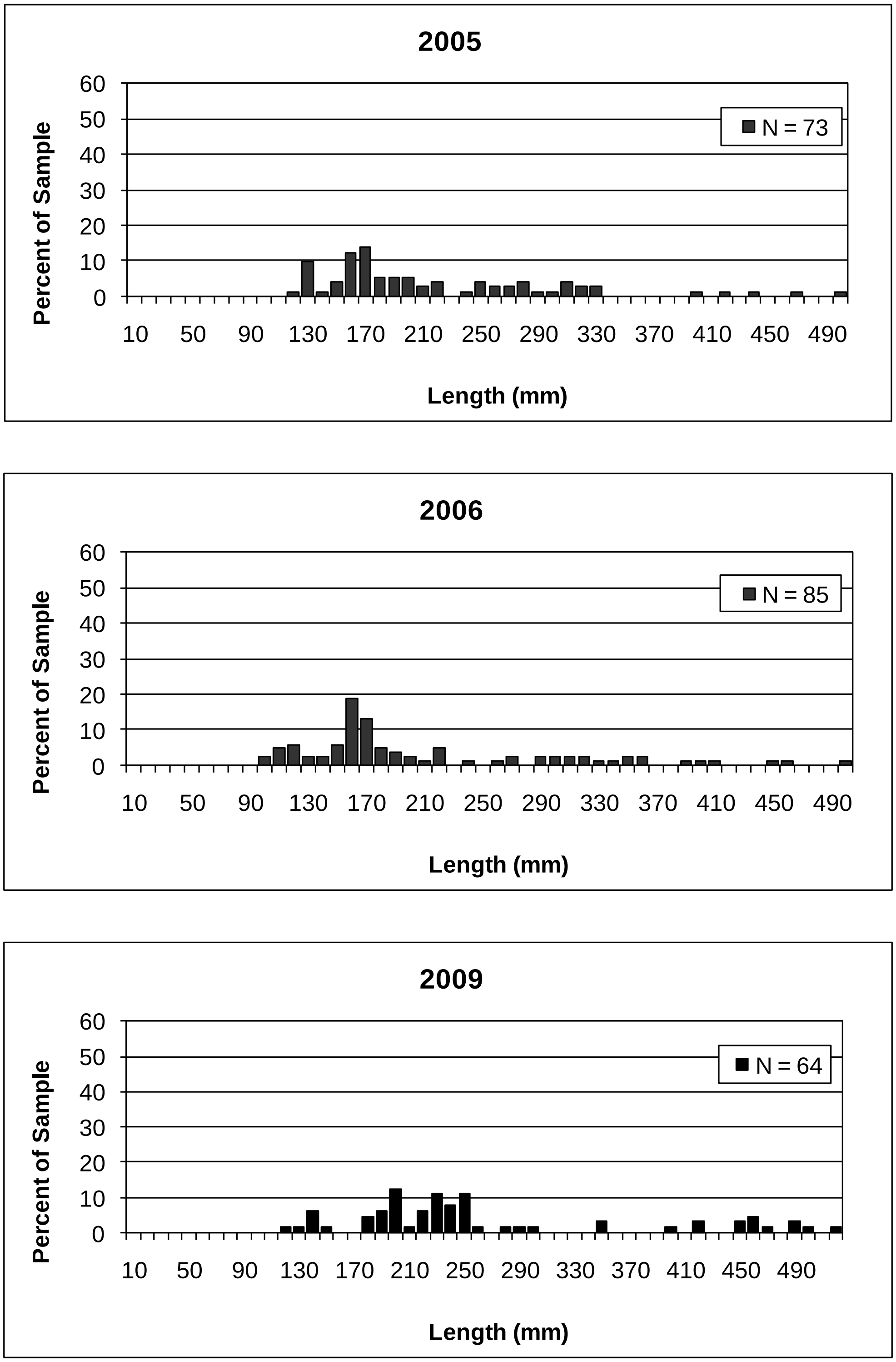


Figure 37. Length frequency distributions of largemouth bass collected from a standard lake survey of Moose Creek Reservoir, Idaho, in 2005, 2006, and 2009.

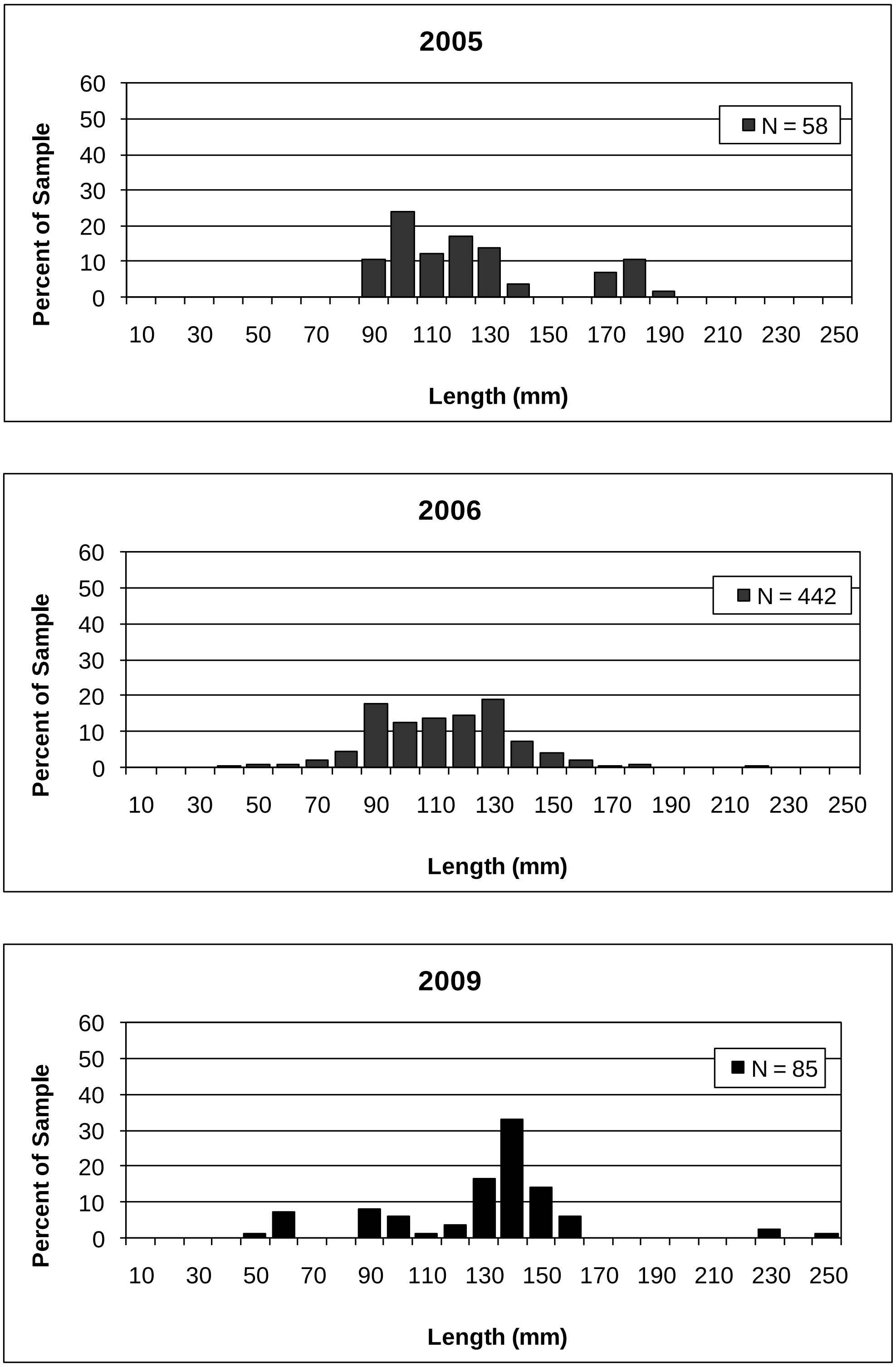
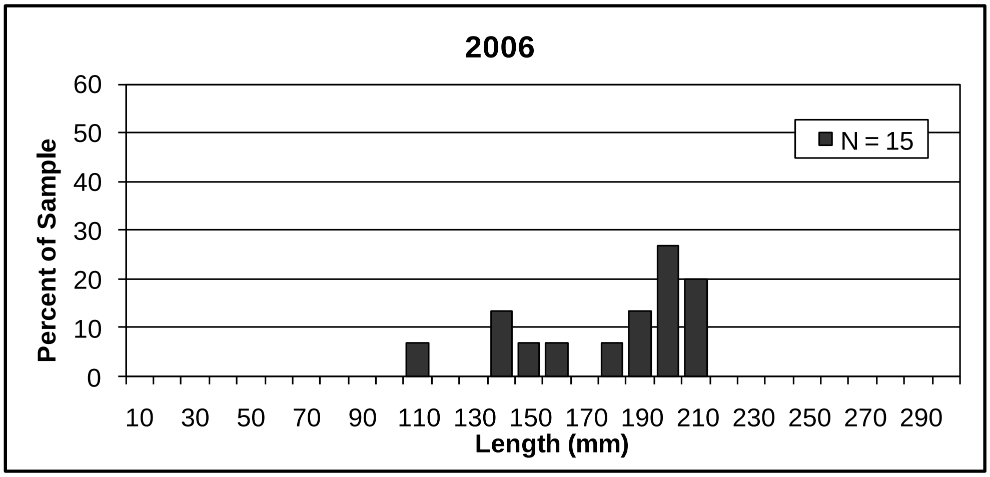


Figure 38. Length frequency distributions of bluegill collected from a standard lake survey of Moose Creek Reservoir, Idaho, in 2005, 2006, and 2009.



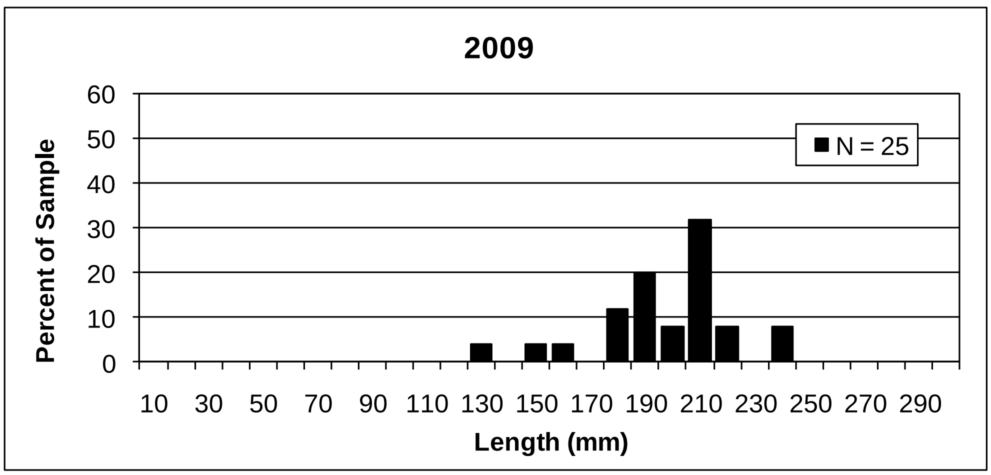


Figure 39. Length frequency distributions of black crappie collected from a standard lake survey of Moose Creek Reservoir, Idaho, in 2005, 2006, and 2009.

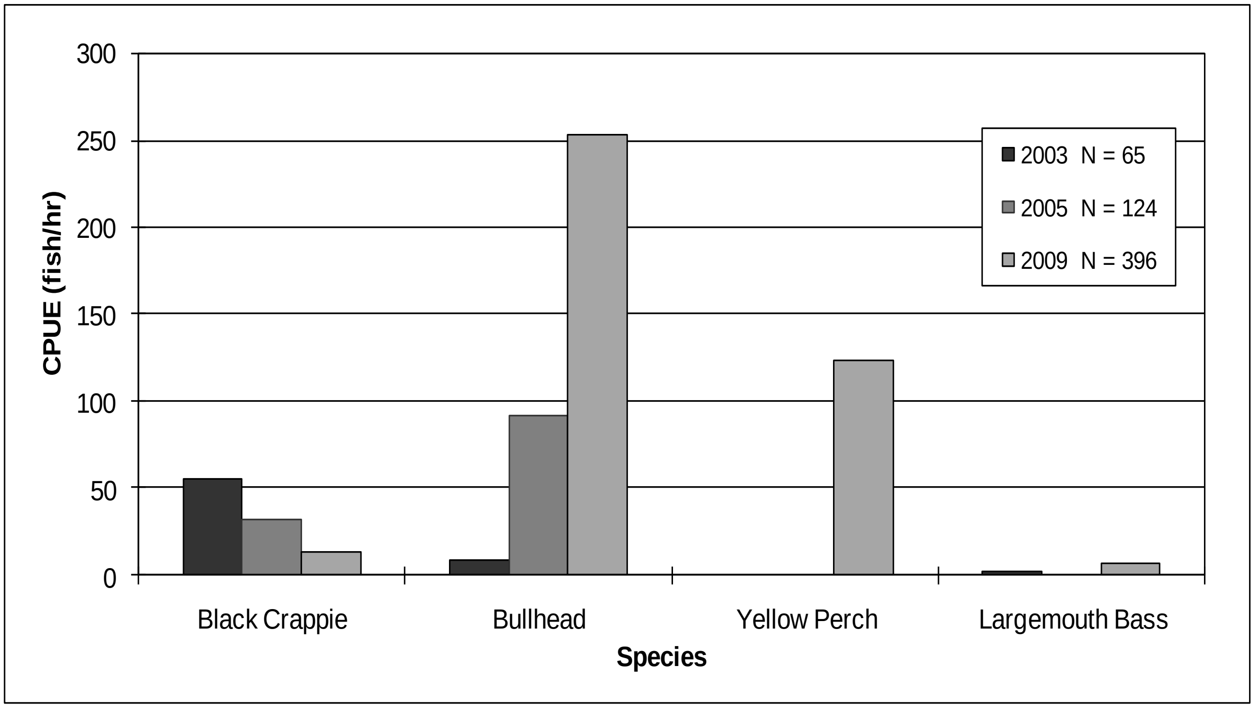


Figure 40. Catch per unit effort (CPUE; fish/hr) of fish collected from standard lake surveys of Soldier's Meadow Reservoir, Idaho, in 2003, 2005, and 2009.

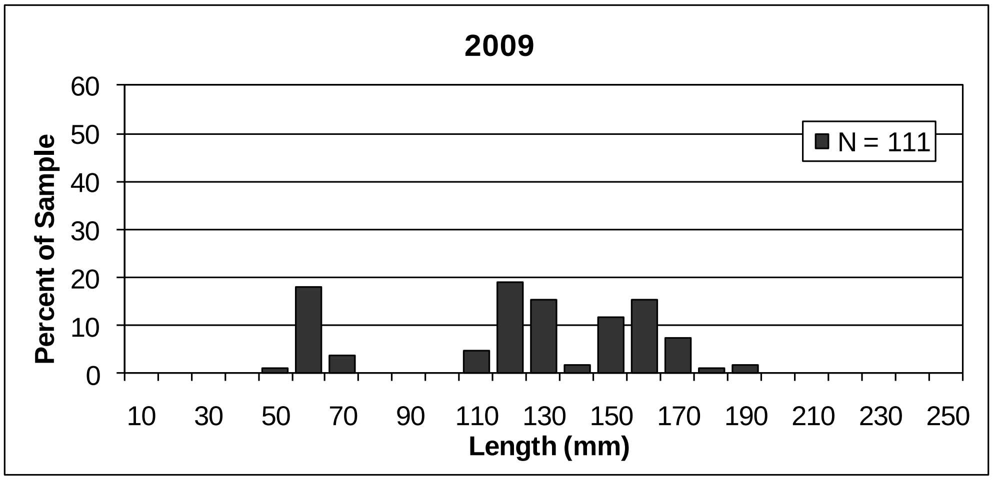


Figure 41. Length frequency distribution of yellow perch collected from a standard lake survey of Soldier's Meadow Reservoir, Idaho, in 2009.

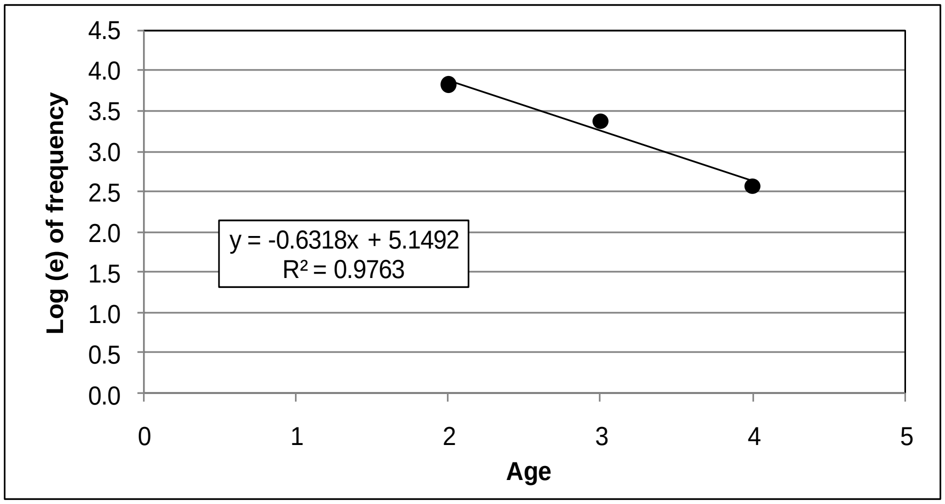


Figure 42. Catch curve for estimating annual mortality of yellow perch collected in Soldier's Meadow Reservoir, Idaho, in 2009.

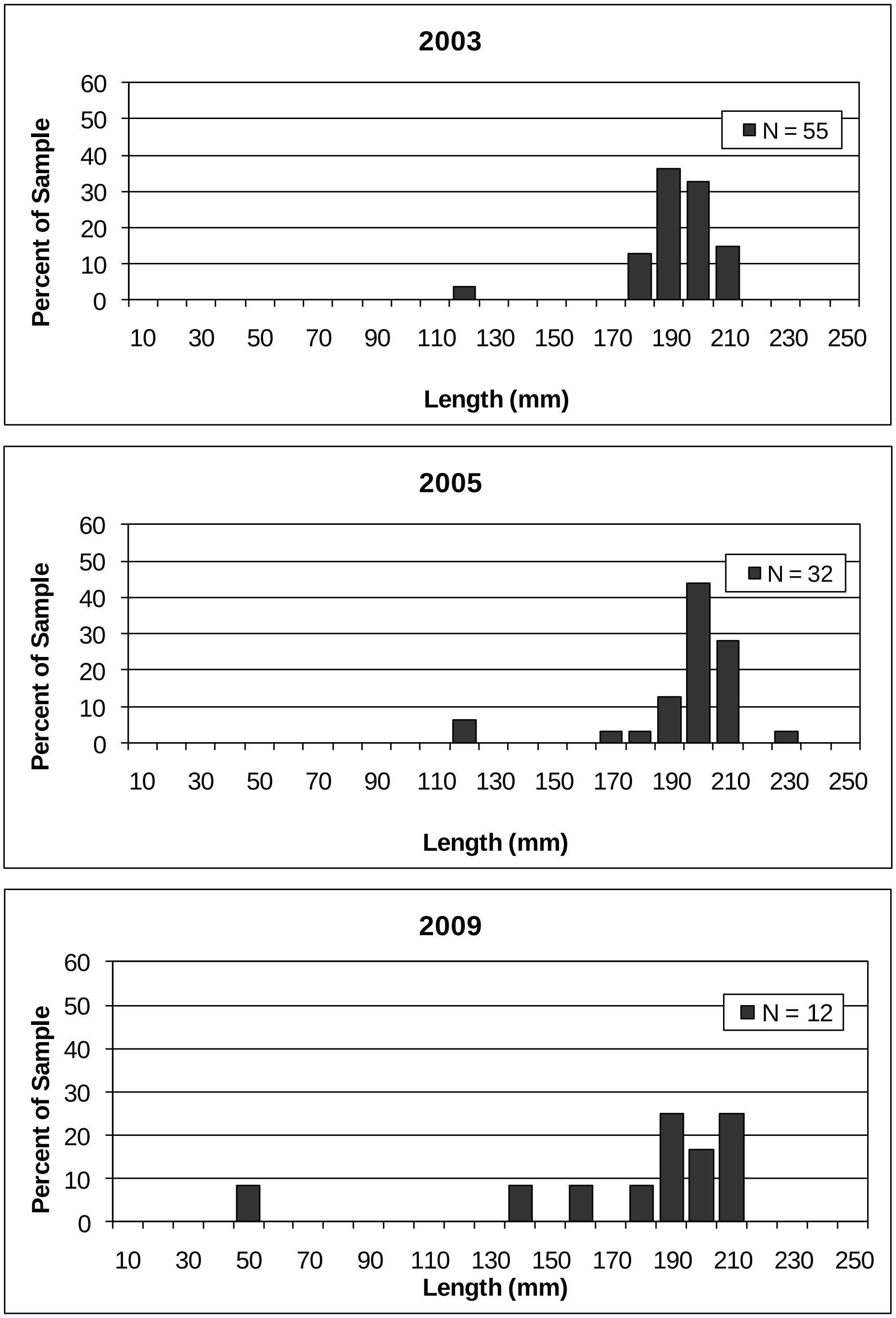
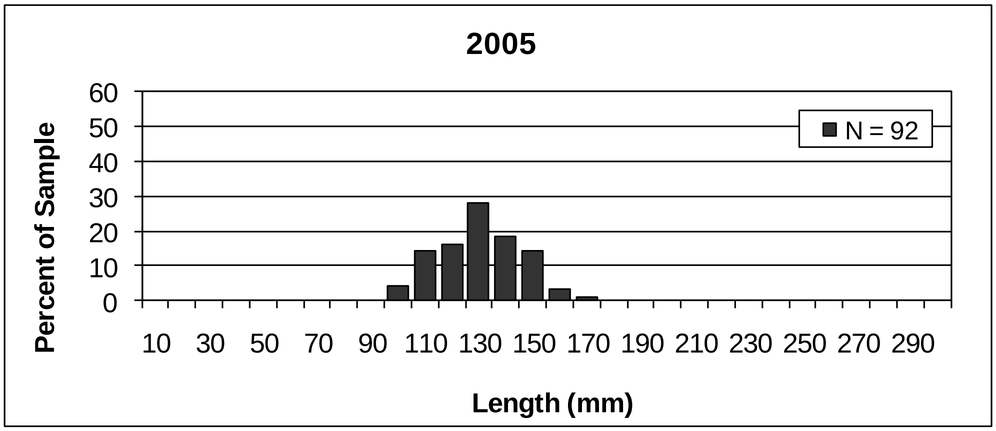


Figure 43. Length frequency distributions of black crappie collected from a standard lake survey of Soldier's Meadow Reservoir, Idaho, in 2003, 2005, and 2009.



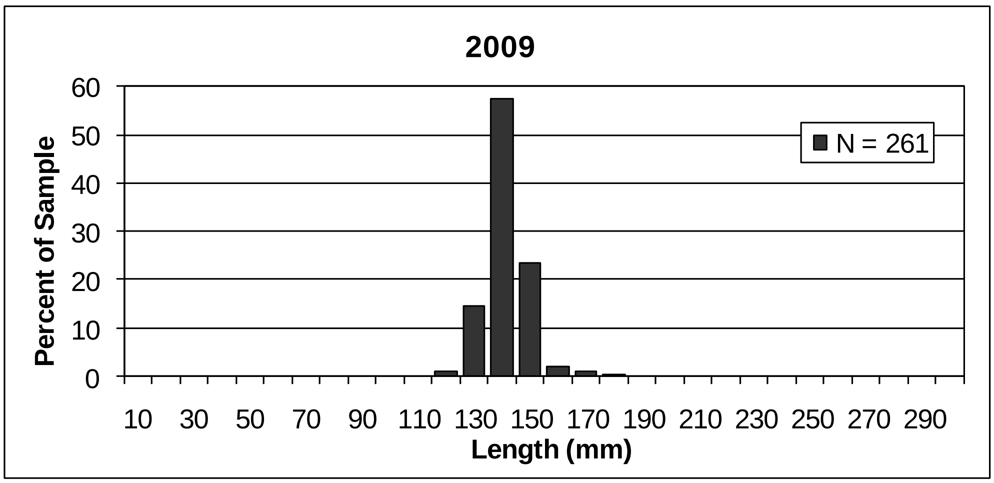


Figure 44. Length frequency distributions of brown bullhead collected from a standard lake survey of Soldier's Meadow Reservoir, Idaho, in 2005 and 2009.

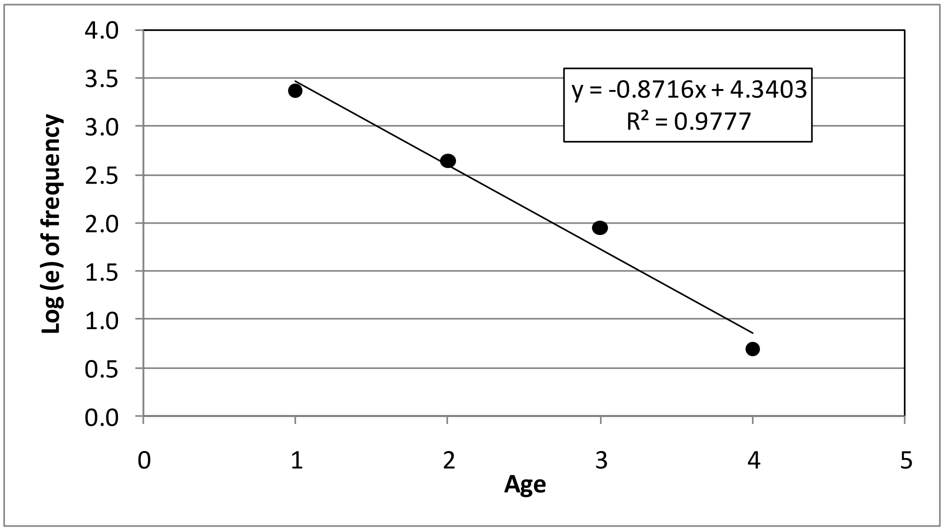


Figure 45. Catch curve for estimating annual mortality of smallmouth bass collected in Waha Lake, Idaho, in 2003.

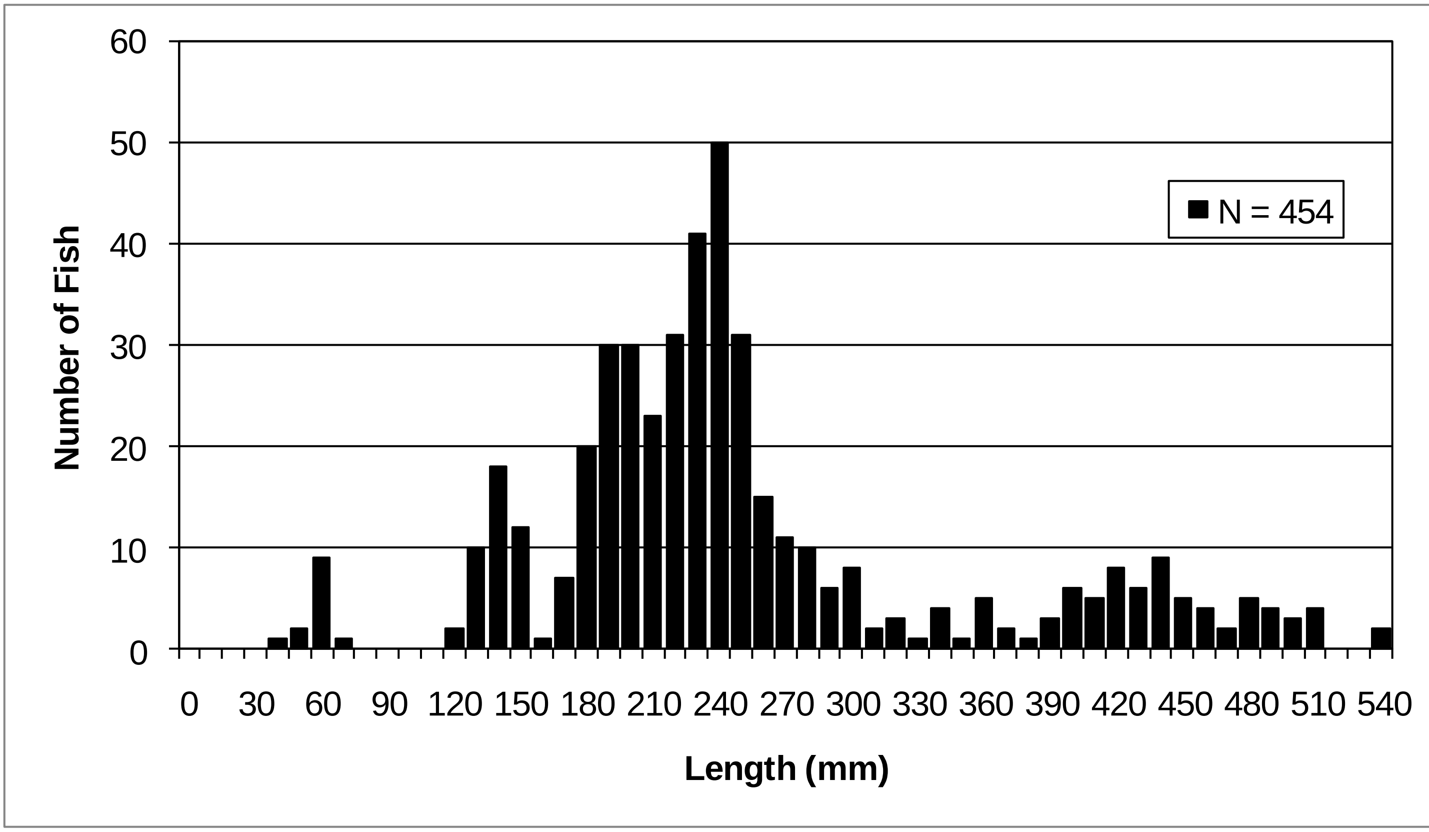


Figure 46. Length frequency distribution of largemouth bass collected during population estimate of Moose Creek Reservoir, Idaho, in 2009.

RIVERS AND STREAMS INVESTIGATIONS

ABSTRACT

Snorkel and hook-and-line surveys were conducted on the Selway River to monitor westslope cutthroat trout *Oncorhynchus clarkii lewisi* populations. A total of 166 NPM sites and 24 1-person sites were snorkeled. A total of 1,196 westslope cutthroat trout were observed during all snorkel transects conducted in the Selway River basin. Of these, 122 (10.2%) were over 305 mm, 39 (3.3%) were over 356 mm, and 11 (0.9%) were over 406 mm. Hook-and-line sampling of westslope cutthroat trout resulted in the capture of 367 fish over six days of sampling. These fish ranged in total length from 142 to 415 mm, with 108 (29.4%) over 305 mm, 54 (14.7%) over 356 mm, and 4 (1.1%) over 406 mm. A total of 21 mortalities were recorded: 12 westslope cutthroat trout (3.3%), 8 rainbow trout (13.1%), and one mountain whitefish (8.3%). Hook scars were present on 21 of the trout collected (4.9%).

Angler exploitation rates were evaluated in the Palouse River and Red River due to the perception that return rates for stocked hatchery rainbow trout *O. mykiss* were low. Results from the exploitation studies confirmed these suspicions, with only 3.8% and 9.6% exploitation rates, respective. These are well below the 40.0% return rate expected for put-and-take fisheries.

Bull trout *Salvelinus confluentus* redd surveys were conducted on the North Fork Clearwater River and Little North Fork Clearwater River. Overall counts declined for the second year after a high of 221 redds in 2007. The trends for streams surveyed annually since 1994 and since 2001 show similar trends, with counts steadily increasing to a high in 2007, then declining the last two years. These declines could be the result of annual fluctuations, but could also be an indication of a decline in the population or a return to equilibrium.

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INTRODUCTION

The State of Idaho has tremendous fisheries resources in its rivers and streams. Managing and monitoring the anadromous and resident populations in these systems is a high priority for fisheries managers. Populations of anadromous salmonids in the Snake River basin experienced tremendous declines following the construction of hydroelectric dams in the Snake and Columbia rivers. Due to this effect, federal management agencies in the basin are required to mitigate for hydroelectric impacts and provide for recovery of all Endangered Species Act (ESA)-listed populations. In addition, IDFG has the long-term goal of preserving naturally reproducing salmon and steelhead *Oncorhynchus mykiss* populations and recovering them to levels that will provide a sustainable harvest. Information such as population density, age composition, recruits per spawner, and survival rates must be estimated annually. This data will guide efforts to meet mitigation and recovery goals.

The Idaho Natural Production Monitoring and Evaluation Project (INPMEP) was developed to provide this information to managers. The Snake River stocks of steelhead and spring/summer Chinook salmon *O. tshawytscha* still have significant natural reproduction and thus are the focal species for this project's investigations. The overall goal is to monitor the abundance, productivity, distribution, and stock-specific life history characteristics of naturally produced steelhead trout and Chinook salmon in Idaho.

In the Clearwater Region, over 150 transects that are part of the long-term Natural Production Monitoring (NPM) database are snorkeled annually by IDFG personnel. Additionally, historical General Parr Monitoring (GPM) sites are snorkeled to maintain long-term trend information. These snorkel surveys provide information on resident species as well. One-man snorkel surveys are also conducted on the Selway River to provide information on trends in length frequency and abundance. To provide further information on westslope cutthroat trout in the Selway River, hook-and-line sampling is conducted. This sampling provides information on trends in size, abundance, and distribution from an angling perspective.

Additionally, bull trout redd surveys were conducted in the North Fork Clearwater River to provide trend information about this ESA-listed species. These surveys were conducted in conjunction with the USFS, Clearwater National Forest office, and IDFG Panhandle Region staff.

OBJECTIVES

1. Assess trends in fish abundance and size in the Selway River through angling surveys and one-person snorkel surveys of historic survey sites.

2. Evaluate angler exploitation rates of hatchery catchable trout in select regional rivers and streams.

3. Evaluate trends in bull trout abundance in the North Fork Clearwater River basin through redd counts.

STUDY AREA

One person snorkel surveys and angling surveys were conducted in the Selway River at locations shown on Figure 47. GPS coordinates and photographs of each site are provided in Hand et al. (2011).

Angler exploitation studies were conducted in the Palouse River and Red River, Idaho (Figure 48). The Palouse River is a tributary of the Snake River, flowing westerly from the Palouse mountain range northeast of Moscow, Idaho, into eastern Washington. The Palouse River basin covers approximately 856,000 ha, and contains 640 km of streams. Eight km before the confluence with the Snake River, the Palouse River drops 55.5 m over Palouse Falls. The height of these falls prevents the upstream migration of fish. Red River is a tributary of the South Fork Clearwater River. Refer to Hand et al. (2011) for a description.

Bull trout redd surveys were conducted by IDFG Clearwater Region personnel in the North Fork Clearwater River drainage, located in Clearwater and Shoshone counties, Idaho (Figure 49). The main stem river is free-flowing for 128.2 km from its headwaters in the Bitterroot mountains to its interface with Dworshak Reservoir. It has a total drainage area of 632,360 ha, with elevations ranging from 2,440 m in the headwaters, to 441 m at Dworshak Reservoir. Most of the drainage is under public ownership by the USFS. The Clearwater National Forest manages 64% of the watershed, and IDFG and the Nez Perce Tribe manage the fisheries resources within the drainage (U.S. Forest Service 2000). Additional surveys were conducted in the Little North Fork Clearwater River drainage by Panhandle Region personnel (Figure 50).

METHODS

Refer to Hand et al. (2011) for descriptions of standard snorkel methodology used for the Natural Production Monitoring project, one person snorkel surveys, and angling surveys in the Selway River.

Angler exploitation rates of catchable size hatchery trout were calculated for the Palouse River and Red River. One hundred hatchery rainbow trout were tagged and released in both the Palouse River and Red River. Two hundred hatchery rainbow trout were tagged and released in Dworshak Reservoir. Tagging, data entry, and analysis was conducted based on the protocols of the IDFG “Tag You’re It”/Fish Data Base program (Mamer et al. 2008).

Bull trout redd surveys were conducted by walking upstream through each transect. IDFG Clearwater Region is responsible for annual surveys of the upper North Fork Clearwater River, Boundary Creek, Long Creek, Goose Creek, and Lake Creek transects. USFS is responsible for annual surveys of Bostonian Creek, Niagara Gulch, Placer Creek, and Vanderbilt Gulch transects. IDFG Panhandle Region is responsible for annual surveys of transects located in the Little North Fork Clearwater River drainage. Other transects may be conducted as time permits by either agency. All redds and scrapes observed were measured for length and width. GPS locations were taken for the start and end point of each transect, and for each redd and scrape. Sightings of live and dead bull trout were noted on data sheets.

RESULTS

Selway River Trend Surveys

The Selway River basin was surveyed July 23 - August 26, 2009 for the NPM project using standard snorkel techniques. A total of 37 sites were surveyed (Figure 47). The average westslope cutthroat trout density was 3.43 fish/100 m^2. Historic average densities for tributaries are shown in Table 37. Results and analysis of data collected on other species can be found in Copeland et al. (In review).

Twenty four 1-person snorkel transects located on the main-stem Selway River (Figure 48) were surveyed to provide basic length-frequency, abundance, and trend information; however, they do not provide density estimates. During 2009, 22 of these transects were snorkeled. Two transects were missed. An average of 11.0 westslope cutthroat trout were observed per transect. Table 38 shows historic numbers of fish observed per transect, by river section.

A hook-and-line survey of westslope cutthroat trout was conducted on the Selway River from July 27 - August 2, 2009. A total of 367 cutthroat trout were collected over six days of sampling. These fish ranged in total length from 142 to 415 mm (Figure 53), with 108 (29.4%) over 305 mm, 54 (14.7%) over 356 mm, and 4 (1.1%) over 406 mm. The average length of westslope cutthroat trout caught in 2009 was 261 mm. Additionally, 61 rainbow trout (110 - 312 mm), 11 hybrid rainbow trout x westslope cutthroat trout (270 - 375 mm), 12 mountain whitefish (240 - 330 mm), and five Chinook salmon smolts were caught. A total of 21 mortalities (4.6%) were recorded: 12 westslope cutthroat trout (3.3%), 8 rainbow trout (13.1%), and one mountain whitefish (8.3%). Hook scars were present on 21 of the trout collected (4.9%).

Angler Exploitation Surveys

Major changes were made to the catchable trout stocking request list in 2009, for stockings beginning in 2010. The total number of fish stocked in the region, and number stocked by each hatchery did not change. Angler exploitation rates were evaluated in the Palouse River and Red River due to the perception that return rates for stocked hatchery rainbow trout were low. A total of 101 fish were tagged in the Palouse River. Two fish were reported caught, with both being harvested. The exploitation rate for the Palouse River was 3.8%. A total of 100 fish were tagged in Red River. Five fish were reported caught, with all five being harvested. The exploitation rate for Red River was 9.6%.

Bull Trout Redd Counts

Bull trout redd surveys were conducted in the North Fork Clearwater River drainage from September 17 - October 1, 2009 (Figure 49) by IDFG Clearwater Region personnel, and included the North Fork Kelly Creek, Lake Creek, Goose Creek, Slate Creek, Long Creek, Boundary Creek, and the upper North Fork Clearwater River. The USFS conducted surveys of Bostonian Creek, Boundary Creek, Niagara Gulch, Placer Creek, Slate Creek, and Vanderbilt Gulch. Additional surveys were conducted in the Little North Fork Clearwater River by IDFG Panhandle Region personnel (Figure 50). A total of 151 redds were observed (Table 39). Potential fish barriers were encountered in the upper North Fork Clearwater River and Boundary Creek transects, and are documented on Figure 49.

DISCUSSION

Selway River Trend Surveys

Westslope cutthroat trout densities generally show a fair amount of fluctuation from year to year, both in the main stem Selway River and in the tributaries. Much of the year to year variation in densities is likely attributable to differences in river conditions when snorkeling occurred. After a basin-wide decline in average westslope cutthroat trout densities was observed from 2003 - 2007, the average density jumped to its highest ever in 2009 at 2.82 fish/100 m^2 (Figure 51). In 2009, overall densities declined in Running Creek and Bear Creek, and increased in Moose Creek, Three Links Creek, White Cap Creek, and Deep Creek. As usual, few fish over 305 mm were observed in tributaries, and the percent of fish observed over 305 mm, 356 mm, and 406 mm dropped for the second straight year (Figure 52). However, since 1990, the percent of fish observed by snorkeling over 305 mm and over 356 mm have shown increasing trends. These trends are similar to those seen by Hardy et al. 2010 in the St. Joe and Coeur d'Alene river systems.

Early studies of westslope cutthroat trout concluded that the low cutthroat trout densities were a result of overfishing (Mallet 1967; Dunn 1968; Rankel 1971). The increasing trends in the Selway could indicate that the catch-and-release regulation put into place in 1976 on the main stem Selway River has been successful in improving the overall size of fish in the river. It must be noted that no data is available prior to 1975, so data on the fishery during harvest regulations cannot be compared to data collected since catch-and-release was instituted.

As with the standard snorkel surveys, the results of the 1-person snorkel transects show substantial fluctuation in the number of westslope cutthroat trout observed from year to year (Figure 53). Even with this annual variation, some of which is likely due to sampler error and natural annual variability, there has been a slight overall downward trend in the average number of fish observed per site since sampling began in 1973 (Figure 51). Trends in numbers for each river section all follow the overall trend quite closely, indicating that no river section is experiencing changes different from the rest of the river.

A hook-and-line survey of westslope cutthroat trout was conducted from July 27 - August 2. A total of 367 fish were caught, the second most fish caught since 2002 (Figure 54). The average length of westslope cutthroat trout caught in 2009 was 261 mm (Figure 55). There has been little change in average length of fish caught by angling since 1975, with average length ranging from 239 - 281 mm. However, since 1975, the percent of fish collected by angling over 305 mm and over 356 mm have shown increasing trends (Figure 52). Many more fish were caught in 2008 and 2009 than in previous years. Angling effort (both number of fishermen and time spent angling) and ability were similar to previous years, which may indicate an increase in abundance in addition to an increase in size.

The minimum mortality rate (observed mortalities) from hook and line sampling was 3.3% for westslope cutthroat trout and 13.1% for rainbow trout. Additional mortality may have occurred after fish were released. The mortality rate for westslope cutthroat trout is within the range of 0.3 - 5.5% mortality seen in most studies involving cutthroat trout (Marnell and Hunsacker 1970, Dotson 1982, Schill et al. 1986), and is very close to the 2.9% seen in 2008. The rate for rainbow trout is well above this range, and is much higher than the 2.9% in 2008. There is no obvious explanation for the increase in mortality over 2008, as angling effort, water conditions, and gear types used were similar to previous years. The level of mortality should be monitored closely over the next few years to see if rates continue at this high level, as this may indicate a need for regulation changes. However, the combination of low fishing pressure on this river (compared to other rivers in the region) and the increasing trend in number of fish observed indicates that the current level of catch and release mortality is not having an effect on the population.

It is likely that differences in water conditions during sampling may have led to some of the fluctuations seen annually in both snorkel densities and in hook-and-line catch rates. In 2008 and 2009, sampling was started with river flows of 1,520 cfs and 1,460 cfs. From 2002 - 2007, sampling was started when river flows were between 865-1,280 cfs, a substantial difference in water levels. As the river level drops, the water temperature tends to increase and the fish in the main stem river may move up into the tributaries or deeper holes for thermal refuge. With more water in 2008 and 2009, more fish may have been in the main stem river. Figure 51 shows the number of fish collected by angling compared to river volume at time of launch. As can be seen, these two parameters track very closely, indicating that catch rates are influenced by water levels. This confirms the recommendation to conduct sampling at similar water levels every year instead of on the same calendar date.

Angler Exploitation Surveys

Most stream stockings in the region were eliminated due to potential impacts to native steelhead populations and low return to creel. As part of our critical review of the regional stocking list, several angler exploitation studies were conducted to determine if these stocking were meeting the objectives of the stocking program. The Palouse River and Red River were studied due to anecdotal information that few of these fish were caught. Results from the exploitation studies confirmed these suspicions, with only 3.8% and 9.6% exploitation rates. These are well below the 40.0% return rate expected for put and take fisheries. While the return rates in Red River and the Palouse River were low, input from Conservation Officers and locals indicated that these stockings are still important. Thus, in 2010, the locations of these stockings will be modified in an attempt to improve return rates. These stockings will now be conducted next to camp grounds and popular recreational sites where more effort will occur, in an attempt to improve return rates. Angler exploitation rates will be assessed again in 2010 to see if the new locations result in improved return rates.

Bull Trout Redd Counts

The total number of bull trout redds counted in 2009 dropped for the second year since peaking at 221 in 2005 (Table 39). In the North Fork Clearwater River, only Placer Creek had fewer redds in 2009 than in 2008. Most of the decline in the past two years came from tributaries to the Little North Fork Clearwater River. This large decrease in number of redds in the Little North Fork Clearwater River could be due to annual fluctuations resulting from weather patterns, changes in habitat quality, fire, and observer variability. The North Fork Kelly Creek was surveyed for the first time since 2001. Only six redds were observed in 2009, compared to 14 observed in 2001. Of the six redds found in 2009, only four were within the survey transect sampled in 2001. Redds were found in few locations containing suitable substrate and flows. More suitable locations may become available in the next few years, as several new channels had been carved out during high water, exposing large quantities of appropriate-sized gravel.

Redd counts from streams surveyed every year were compiled to provide long term trend information (Figure 56). As can be seen, the trends for streams surveyed annually since

1994 and since 2001 show similar trends. These counts steadily increased to a high in 2007, then have declined the last two years. However, there is still an overall upward trend in redd numbers since 1994. This is a similar trend to that seen in Pend Oreille Lake tributaries and the St. Joe's River in Idaho's Panhandle Region (Hardy et al. 2010). With similar trends seen in several systems in northern Idaho, the declines seen over the last two years are likely the result of natural fluctuations or a return to equilibrium.

MANAGEMENT RECOMMENDATIONS

1. Conduct annual Selway River snorkel survey when river flows are between 1,200 – 1,500 cfs to reduce potential environmental bias in survey results.

2. Re-evaluate angler exploitation of hatchery rainbow trout in Red River and Palouse River using new stocking locations near campgrounds and recreational sites.

3. Assist with bull trout redd surveys in the North Fork Clearwater River basin to maintain historic trend information.

Table 37. Densities (fish/100 m^2) of westslope cutthroat trout as determined by snorkel surveys in major tributaries of the Selway River, Idaho, 1988 - 2009.

Westslope cutthroat trout > 305 mm

Tributary	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Running Creek	0.29	0.00	0.32	0.37	0.27	0.00	0.23	0.16	0.00	0.00	0.00	0.00		0.00	0.09	0.00	0.09	0.08		0.00	0.08	0.00
Bear Creek	0.70	0.00	0.23	0.00	0.24	0.22	0.00	0.00	0.00	0.12	0.09	0.17		0.10	0.25	0.00	0.00	0.26		0.10	0.05	0.07
Moose Creek	0.00	0.00	0.05	0.08	0.15	0.22	0.21	0.20	0.08	0.14	0.06	0.04		0.29	0.12	0.25	0.22	0.28		0.20	0.15	0.16
Three Links Creek	0.00	0.00	0.00	0.00	0.00	0.45	0.60	0.27	0.33	1.13	0.26	0.25		1.06			0.27	0.00		0.00	0.00	0.00
Marten Creek					0.66		0.69	0.33	0.00	0.32	0.39	0.00		0.00	0.00	0.00	0.00	0.00		1.92	0.00	
White Cap Creek	0.11	0.06	0.04	0.07	0.00	0.20	0.38	0.04	0.02	0.04	1.86	0.02		0.15		0.09	0.08	0.05	0.04	0.03	0.02	0.02
Deep Creek	0.09	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
O'hara Creek						0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08					
Meadow Creek	0.00		0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.04	0.13	0.20	0.07	0.00				
Littlle Clearwater River							0.36	0.00	0.00	0.00	0.10	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
Gedney Creek			0.00	0.00	0.05	0.00	0.00	0.00	0.07	0.22	0.06	0.00	0.00	0.00	0.00	0.00	0.00			0.00		
Average	0.17	0.01	0.08	0.06	0.15	0.13	0.23	0.09	0.05	0.18	0.26	0.05	0.00	0.15	0.07	0.05	0.08	0.07	0.01	0.25	0.04	0.04

All westslope cutthroat trout

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Running Creek	0.88	0.48	0.43	1.47	1.72	0.35	0.77	1.21	0.07	0.33	0.83	0.00		0.00	0.46	0.13	0.37	1.18		0.70	0.24	0.08
Bear Creek	0.70	0.00	0.23	0.00	0.77	0.57	0.39	0.71	0.55	0.43	0.78	1.11		1.29	0.75	0.61	0.00	0.78		1.40	0.36	0.21
Moose Creek	0.00	0.00	0.25	0.49	0.93	0.75	0.88	0.46	0.59	0.21	0.45	0.75		0.92	0.76	0.84	0.94	1.45		0.88	0.84	0.89
Three Links Creek	0.00	0.00	0.00	0.00	2.85	0.45	2.41	1.37	1.00	3.68	0.77	3.54		2.12			1.09	2.25		1.77	0.52	0.97
Marten Creek					1.65		1.38	1.63	0.26	0.32	8.27	2.95		7.78	11.20	0.00	12.69	0.00		5.77	4.35	
White Cap Creek	0.56	0.87	0.76	0.89	2.71	0.86	2.17	0.71	1.13	0.62	8.55	0.71		0.89		0.31	0.35	0.32	0.64	0.46	0.36	0.51
Deep Creek	1.10	1.35	0.19	1.71	2.86	3.71	3.62	2.35	2.30	0.20	1.99	3.13		2.48	4.71	25.98	18.15	6.87	1.18	2.85	1.35	5.89
O'hara Creek						0.00	0.00	0.00		0.25	0.13	2.21	0.00	0.00	0.00	0.00	0.16					
Meadow Creek	0.08		0.13	0.24	0.35	0.26	0.87	0.46	0.25	0.05	1.63		0.06	0.25	0.42	0.79	0.62	0.53				
Littlle Clearwater River							1.20	0.12	0.44	0.10	0.30	1.64		1.25	0.82	1.45	0.00	2.47	0.54	0.41		
Gedney Creek			0.00	0.33	0.10	0.68	0.00	0.00	0.12	0.29	0.12	0.00	0.00	0.17	0.28	0.58	0.52			0.00		
Average	0.48	0.45	0.25	0.64	1.55	0.85	1.24	0.82	0.67	0.59	2.17	1.60	0.02	1.56	2.16	3.07	3.17	1.76	0.79	1.58	1.14	1.43

Table 38. Average number of westslope cutthroat trout per transect as determined by 1-person snorkel surveys in the main-stem Selway River, Idaho, 1973 - 2009.

Westslope cutthroat trout > 305mm

River Section	1973	1974	1975	1976	1977	1978	1980	1982	1984	1986	1988	1990	1992	1994	1995	1996	1997	1998	1999	2001	2002	2003	2004	2005	2007	2008	2009
White Cap Creek Running Creek	0.4	0.6	0.8	1.6	2.4	1.2	1.7	1.0	1.7	3.2	3.3	2.0	0.3	0.5	0.0	0.0	0.5		1.0	3.7	5.7	0.7	1.0	4.0	0.3	2.7	0.0
Running Creek to Bear Creek	0.8	0.4	1.2	1.0	4.0	2.2	2.2	1.2	3.6	2.8	2.6	2.6	2.4	1.0	0.0	0.0	3.0		0.3	5.0	4.3	1.7	1.0	1.0	2.0	1.8	0.3
Bear Creek to Moose Creek	1.8	1.2	0.4	1.5	4.4	4.2	1.6	2.4	4.4	4.0	5.0	1.2	3.0	1.0	1.2	0.0	1.5	0.0	2.8	4.2	2.3	3.3	1.4	0.9	0.7	2.0	0.8
Moose Creek to Three-Links Creek	0.6	1.3	0.7	1.9	3.3	3.1	3.9	4.2	6.2	5.9	5.8	1.4	0.3	0.0	0.3	0.9	1.6	0.3	3.4	2.3	2.2		1.7	3.4	0.0	0.8	2.8
Three Links Creek to Race Creek	1.2	0.3	1.4	1.2	2.5	3.0	1.8	3.5	4.8	3.6	3.2	3.7	0.9	0.0	0.0	3.0	2.3	3.0	1.0	0.7	0.8		0.5	1.8	5.0	0.8	4.3
Average	1.0	0.7	0.9	1.4	3.3	2.7	2.2	2.5	4.1	3.9	4.0	2.2	1.4	0.5	0.3	0.8	1.8	1.1	1.7	3.2	3.1	1.9	1.1	2.2	1.6	1.6	1.6

All westslope cutthroat trout

River Section	1973	1974	1975	1976	1977	1978	1980	1982	1984	1986	1988	1990	1992	1994	1995	1996	1997	1998	1999	2001	2002	2003	2004	2005	2007	2008	2009
White Cap Creek Running Creek	4.2	3.4	6.8	7.2	10.8	7.4	13.2	11.2	11.0	15.2	13.3	6.8	4.8	7.5	13.0	10.7	6.0		17.0	13.3	12.7	10.3	8.0	13.5	2.3	15.3	6.7
Running Creek to Bear Creek	7.2	4.8	6.6	6.2	18.6	10.6	18.6	11.2	17.4	19.2	11.6	16.4	9.4	9.0	13.3	15.5	26.5		12.6	12.7	21.0	8.3	5.0	6.0	4.5	8.5	4.0
Bear Creek to Moose Creek	5.3	7.5	5.0	6.0	17.4	19.6	16.0	16.2	19.4	21.4	21.8	7.4	6.2	8.3	13.3	15.0	7.8	1.0	16.6	7.5	8.6	10.6	7.0	8.4	3.6	15.0	10.2
Moose Creek to Three-Links Creek	4.5	8.2	6.3	8.8	22.0	20.9	21.7	20.3	25.7	26.1	24.3	6.8	4.4	3.0	6.0	8.5	10.5	2.0	10.6	5.3	12.6		12.0	19.8	1.8	14.8	21.4
Three Links Creek to Race Creek	5.0	3.4	4.6	6.1	9.3	9.8	17.2	20.8	16.3	24.6	17.4	11.7	3.0	6.0	6.4	30.0	15.0	7.6	4.2	1.3	2.2		5.5	6.7	15.3	10.3	12.5
Average	5.2	5.5	5.9	6.9	15.6	13.6	17.3	15.9	17.9	21.3	17.7	9.8	5.6	6.8	10.4	15.9	13.2	3.5	12.2	8.0	11.4	9.7	7.5	10.9	5.5	12.8	11.0

Table 39. Number of bull trout redds observed in tributaries of the North Fork Clearwater River and Little North Fork Clearwater River, 1994 - 2009.

Stream Surveyed	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
North Fork Clearwater River	--	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--
Black Canyon	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
Bostonian Creek	0	0	0	0	0	4	1	1	1	18	12	15	14	26	13	15
Boundary Creek	--	--	--	--	--	--	--	--	--	2	3	10	--	--	--	0
Collins Creek	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--
Goose Creek	--	--	--	--	--	--		1	0	2	1	12	8	1	0	2
Hidden Creek	--	--	--	--	--	--	--	--	1	0	--	--	--	--	--	--
Isabella Creek	--	--	--	--	--	--	--	--	1	1	0	0	--	1	1	--
Kelley Creek - North Fork	--	--	--	--	--	--	--	14	--	--	--	--	--	--	--	6
Lake Creek	--	--	--	--	--	--	19	7	20	14	5	2	5	3	0	2
Little Moose Creek	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--
Long Creek	--	--	--	--	--	--	0	0	5	0	8	10	1	6	10	11
Moose Creek	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	--
Niagra Gulch	--	--	--	--	--	--	2	5	6	10	3	4	2	2	2	4
Orogrande Creek	--	--	--	--	--	--	--	--	--	--	--	0	--	--	--	--
Osier Creek	--	--	--	--	--	--	3	0	2	0	--	--	--	--	--	--
Placer Creek	3	1	2	2	2	7	4	2	4	6	2	3	5	2	3	1
Pollock Creek	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--
Quartz Creek	--	--	--	--	--	--	--	4	0	0	0	0	--	--	8	--
Ruby Creek	--	--	--	--	--	0	0	--	--	--	--	--	--	--	--	--
Skull Creek	--	--	--	--	--	--	--	--	0	6	5	3	--	4	9	--
Slate Creek	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	0
Swamp Creek	--	--	--	--	--	--	2	0	1	0	0	2	--	1	--	--
Upper NF	--	--	--	--	--	--	--	--	--	7	3	6	--	--	--	0
Vanderbilt Gulch	--	--	--	--	--	--		24	18	13	12	41	35	39	43	49
Weitas Creek	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--
Windy Creek	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--
Breakfast Creek																
Floodwood Creek	--	--	--	--	--	--	--	--	4	0	0	--	--	--	--	--
Gover Creek	--	--	--	--	--	--	--	--	--	1	0	--	--	--	--	--
Stony Creek	--	--	--	--	--	--	--	--	4	0	0	--	--	--	--	--
Little North Fork Clearwater River																
Buck Creek	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--
Canyon Creek	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--	--
Butte Creek	--	--	--	--	--	--	--	5	0	--	--	--	--	--	--	--
Rutledge Creek	--	--	--	--	--	--	--	--	--	1	1	6	0	--	--	--
Rocky Run Creek	--	--	--	--	--	--	--	--	5	1	3	21	13	8	--	8
Lund Creek	0	7	2	2	1	1	13	5	7	8	5	19	7	30	22	11
Little Lost Lake Creek	0	1	1	1	7	3	1	--	6	7	16	1	38	36	14	5
Lost Lake Creek	0	0	0	0	--	1	--	--	0	--	1	--	10	13	8	9
Little North Fork Clearwater River																
1268 Bridge to Lund Cr.	--	--	--	--	--	--	--	17	6	13	8	16	18	20	13	3
Lund Cr. to Lost Lake Cr.	--	--	3	1	9	8	3	12	7	7	5	8	16	21	9	11
Lost Lake Cr. to headwaters	0	2	0	0	--	5	1	--	5	6	5	11	13	8	20	14
Total for all streams	3	11	8	6	19	31	50	97	104	129	98	193	185	221	175	151

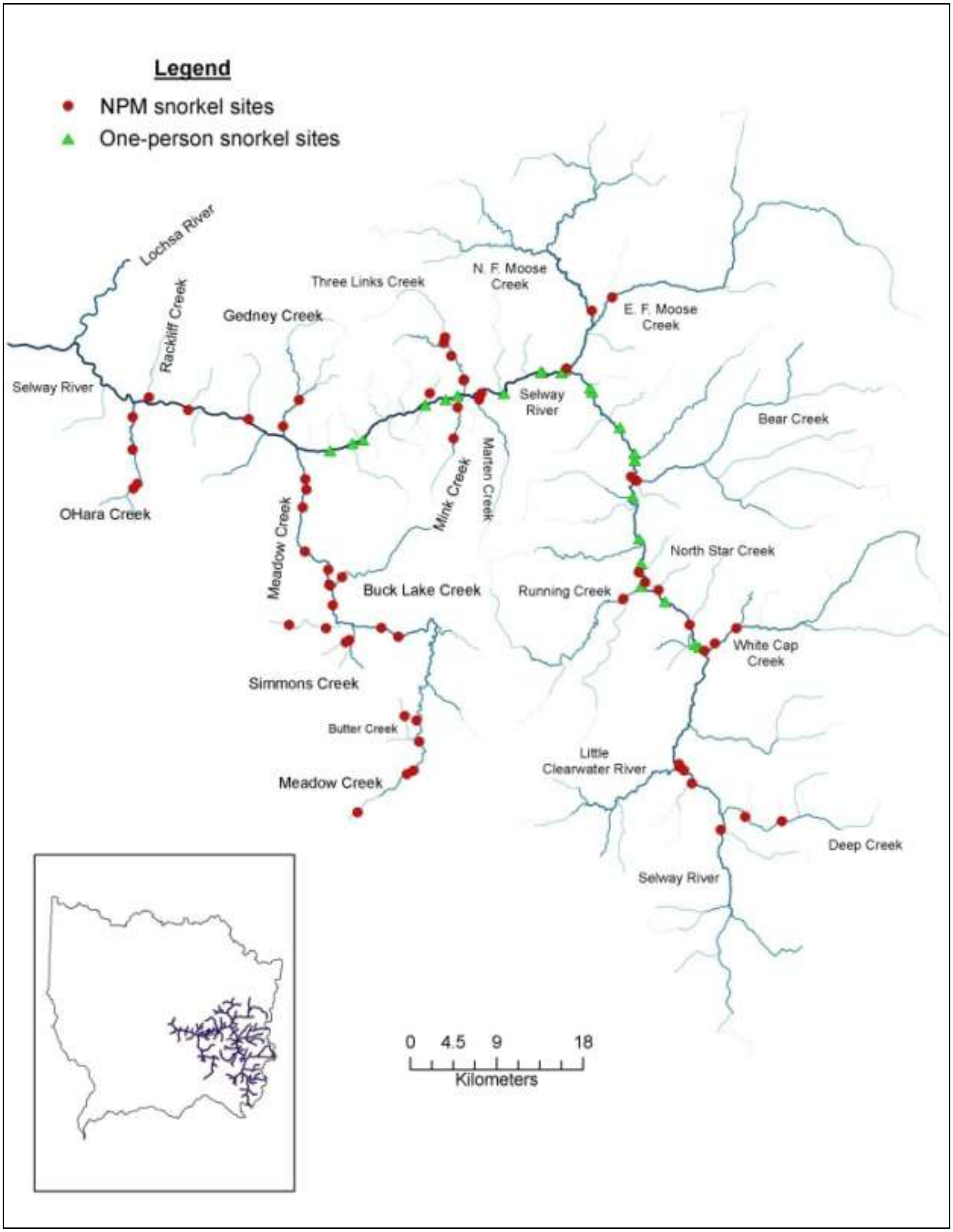


Figure 47. Map of snorkel sites surveyed in the Selway River basin, Idaho, in 2009.

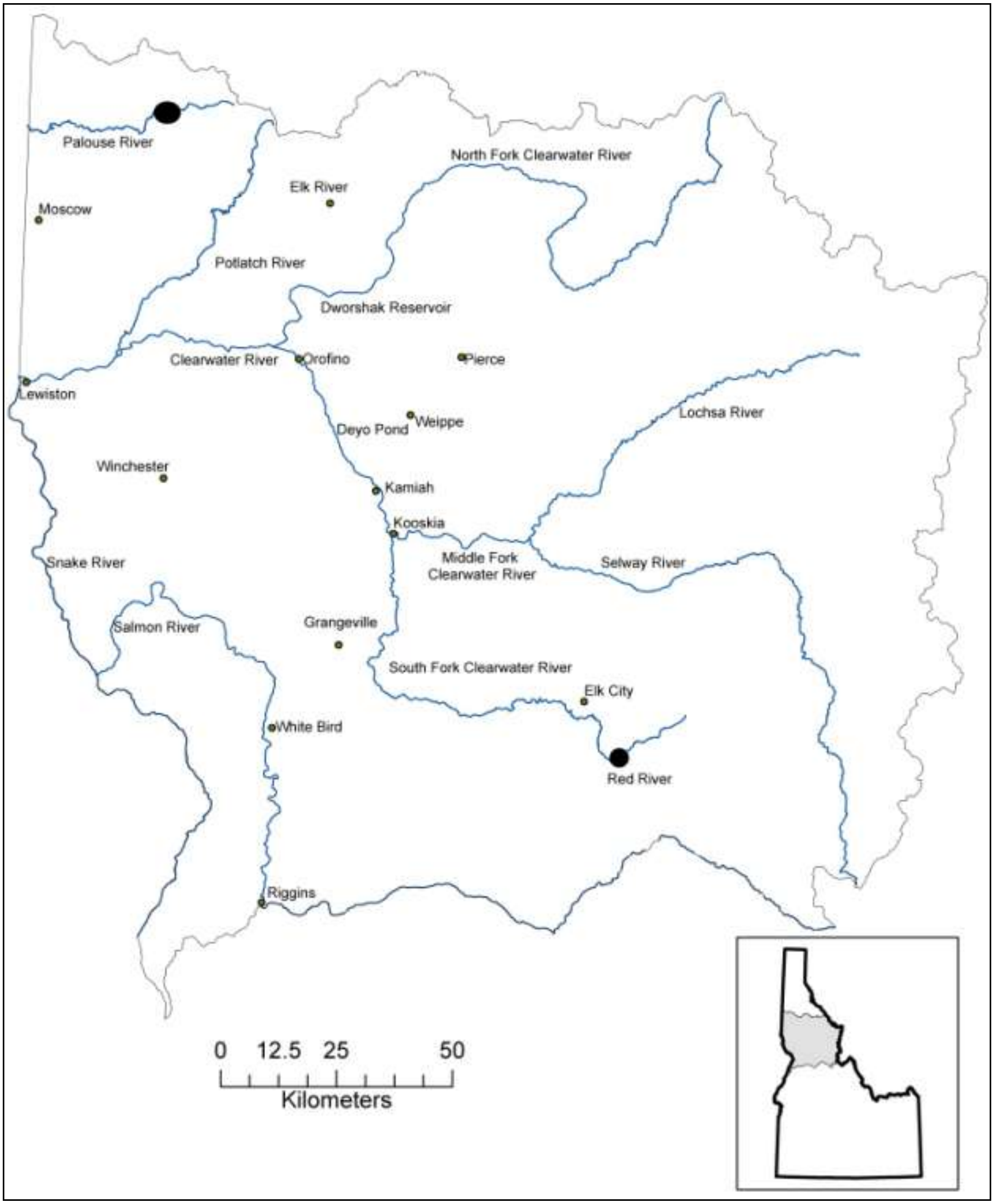


Figure 48. Map showing fish stocking locations on the Palouse River and Red River, Idaho, for angler exploitation studies conducted in 2009.

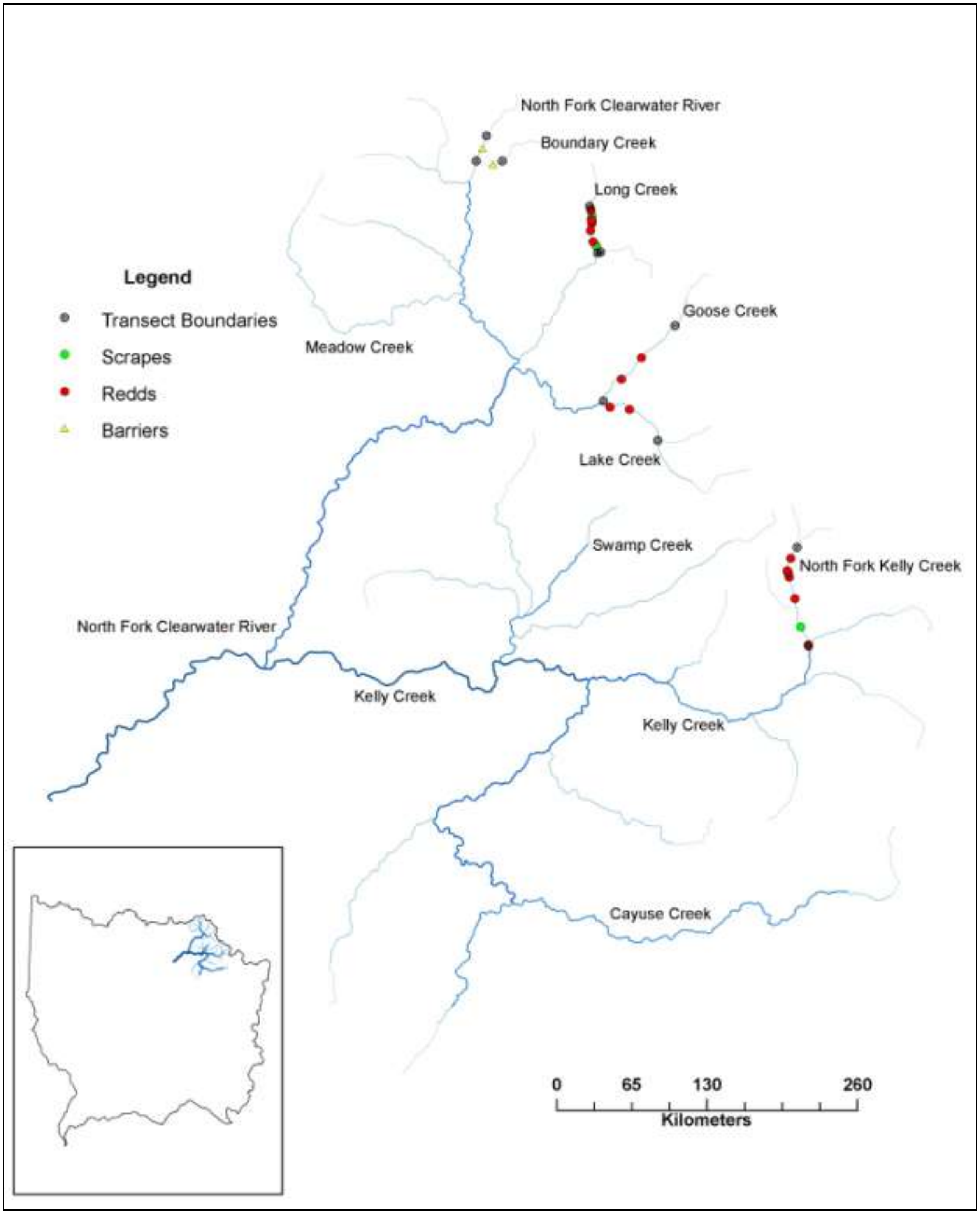


Figure 49. Bull trout redd surveys conducted in the North Fork Clearwater River, Idaho, 2009.

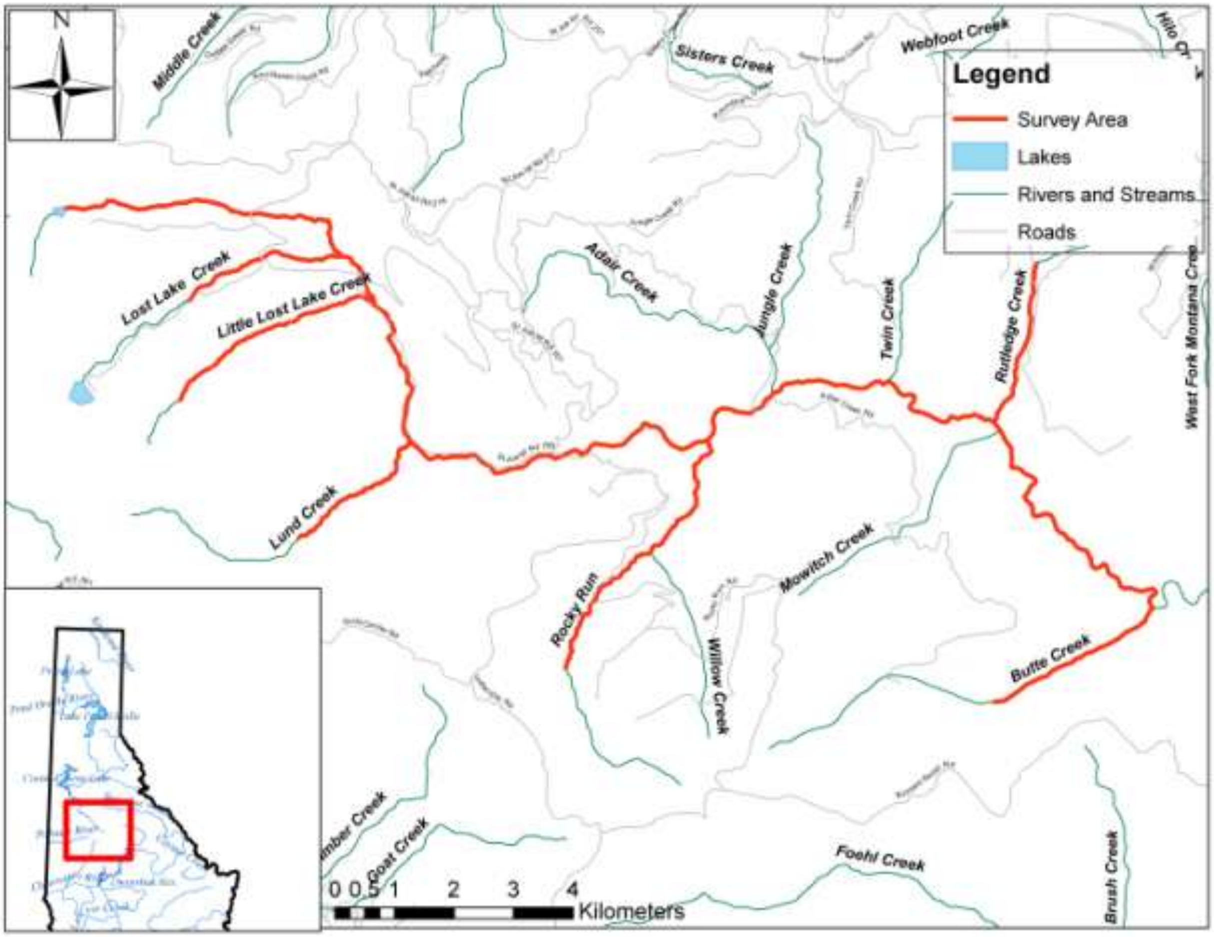


Figure 50. Locations of bull trout redd survey transects conducted in the Little North Fork Clearwater River, Idaho, 2009.

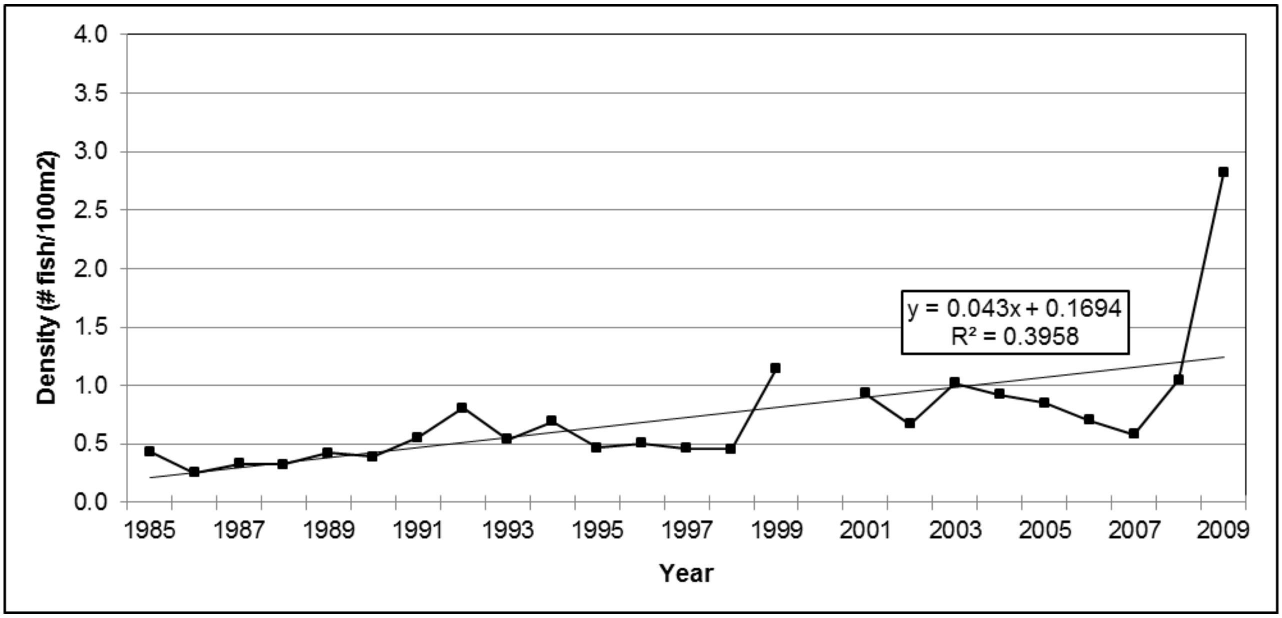
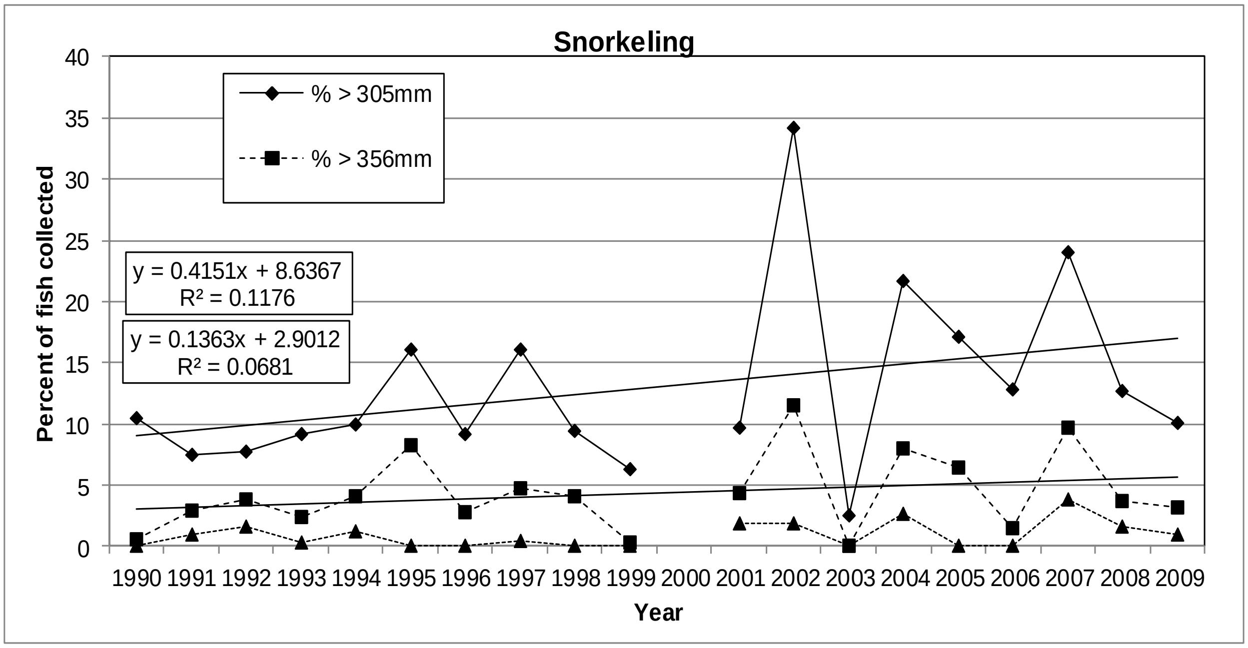


Figure 51. Basin-wide densities (fish/100 m^2) of westslope cutthroat trout as determined by snorkel surveys in the Selway River basin, Idaho, 1985-2009.



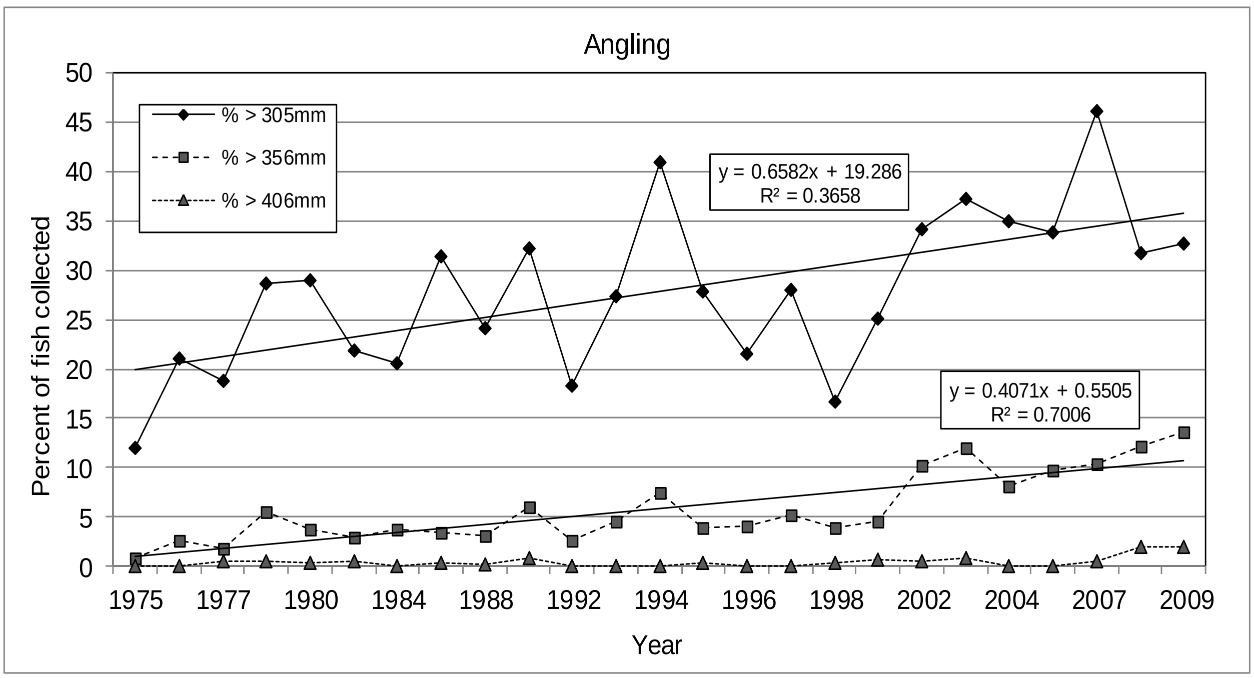


Figure 52. Percent of westslope cutthroat trout collected by snorkeling and angling in the Selway River, Idaho, above lengths of 305 mm, 356 mm, and 406 mm.

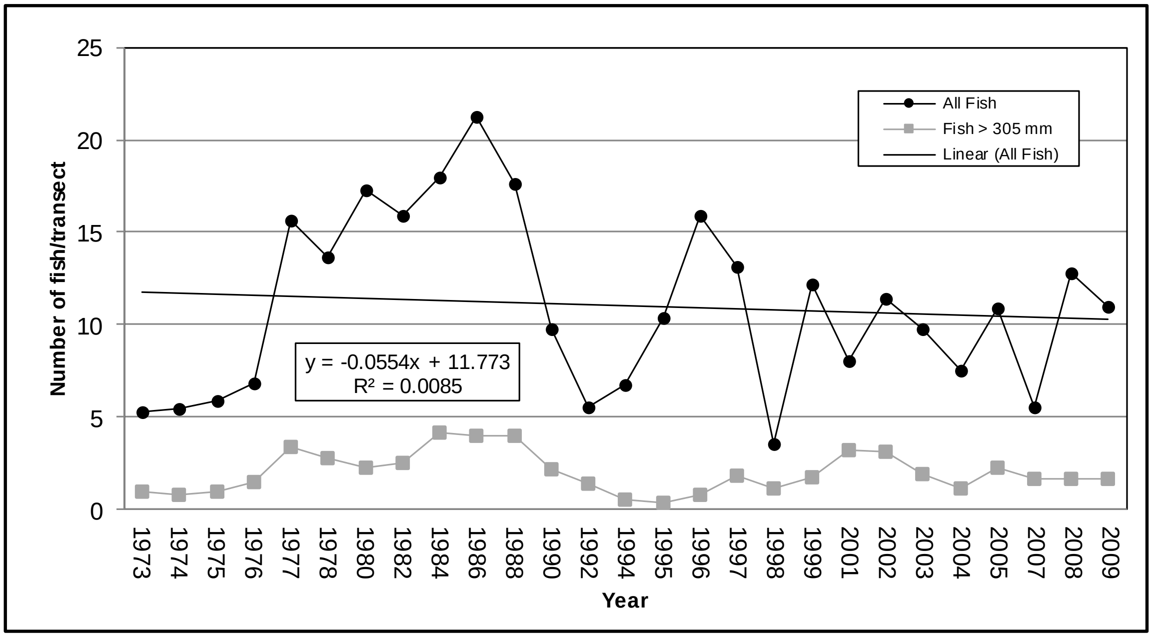


Figure 53. Average number of westslope cutthroat trout per transect as determined by 1-person snorkel surveys in the main-stem Selway River, Idaho, 1973 - 2009.

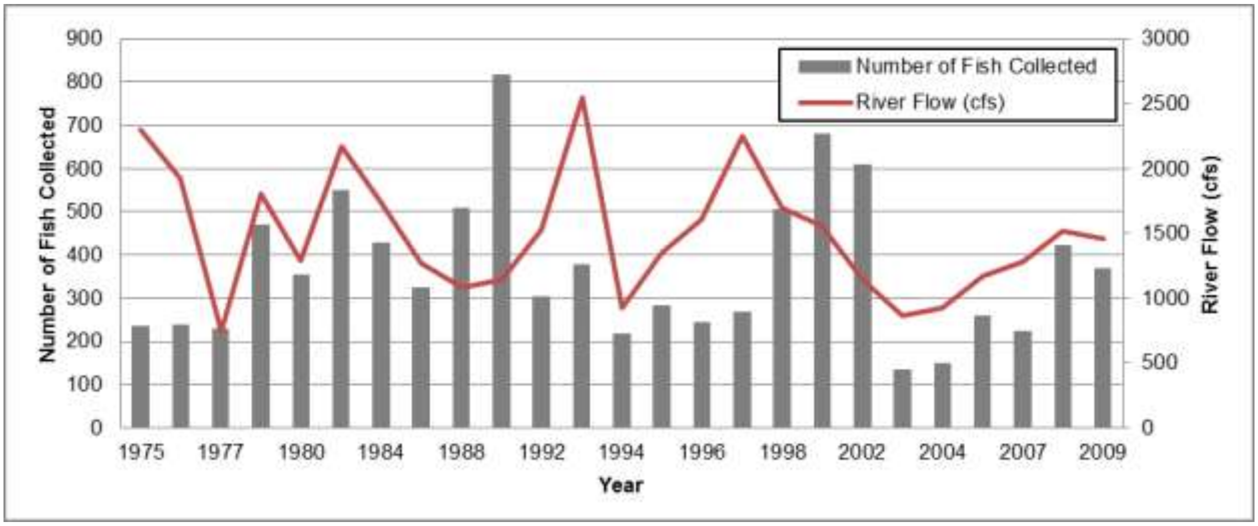


Figure 54. Number of fish caught by angling in the Selway River, Idaho, compared to river volume at time of launch, 1975 - 2009.

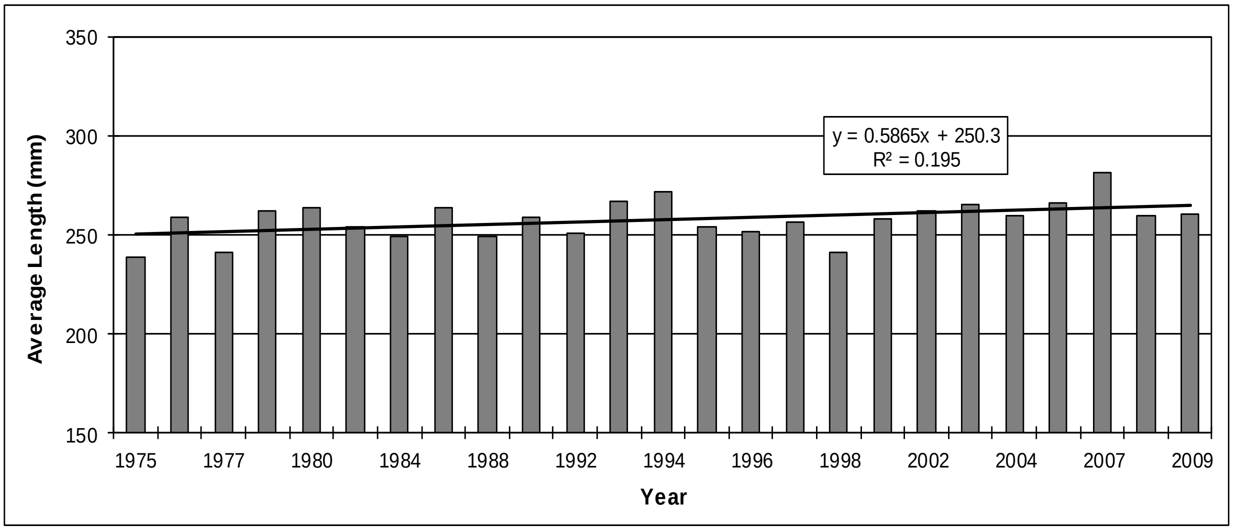


Figure 55. Average length of westslope cutthroat trout collected by angling in the Selway River, Idaho, from 1975 – 2009.

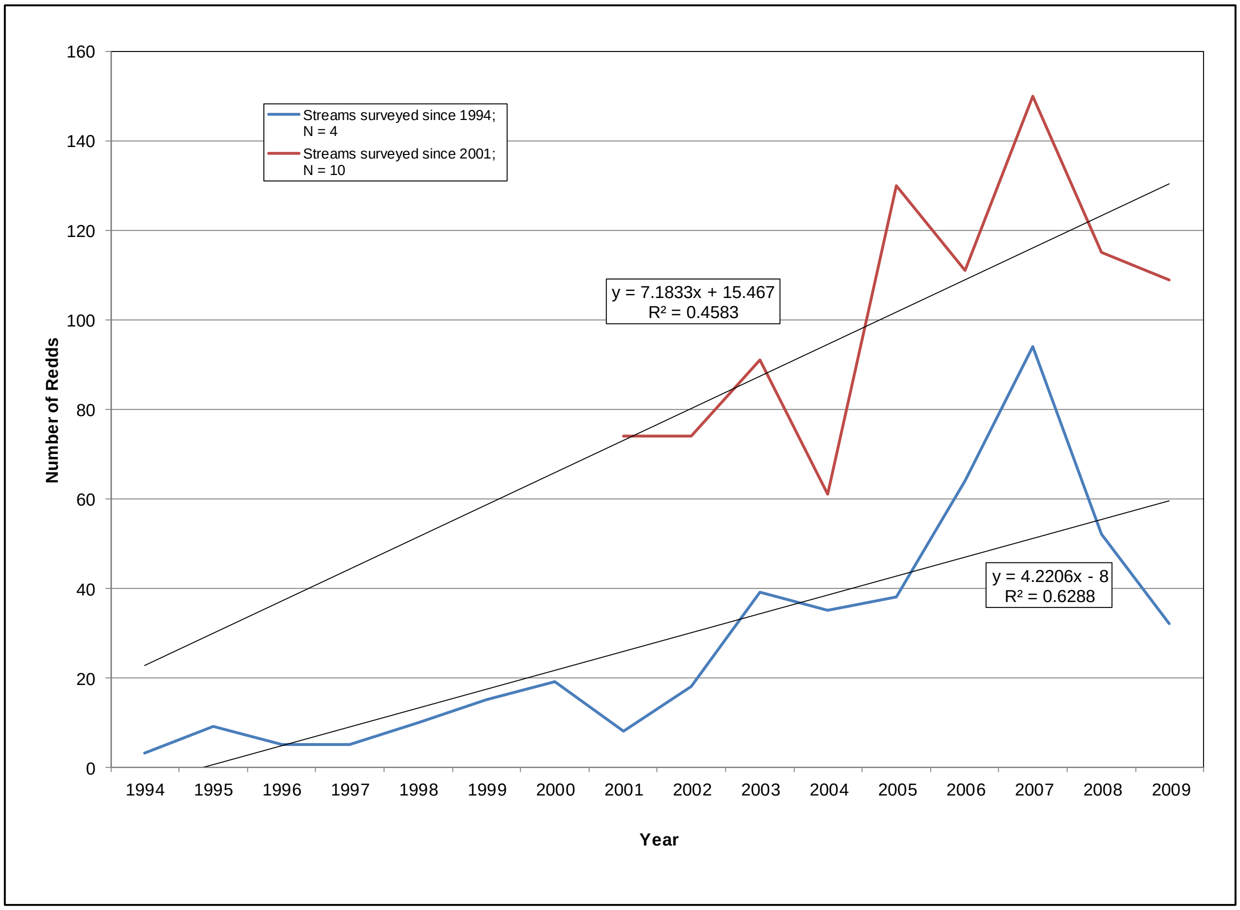


Figure 56. Number of bull trout redds counted in streams surveyed annually since 1994 (Bostonian Creek and Placer Creek in the North Fork Clearwater River drainage, and Lund Creek and Lost Lake Creek in the Little North Fork Clearwater River drainage) and in streams surveyed annually since 2001 (includes the four streams listed above plus Goose, Lake, Long, Niagara, and Vanderbilt Gulch creeks in the North Fork Clearwater River and the sections of the Little North Fork Clearwater River from 1268 Bridge to Lund Creek, and Lund Creek to Lost Lake Creek).

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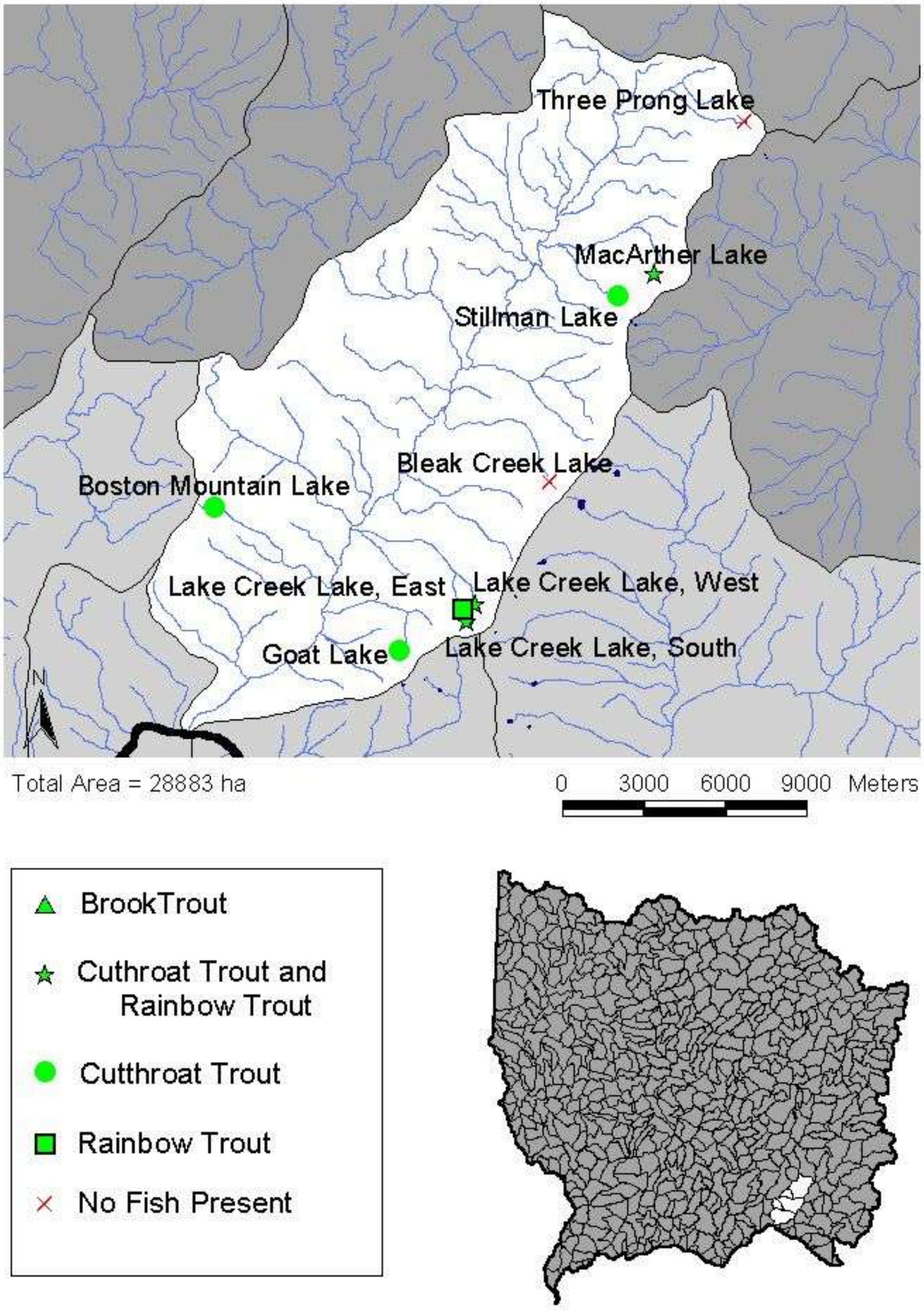
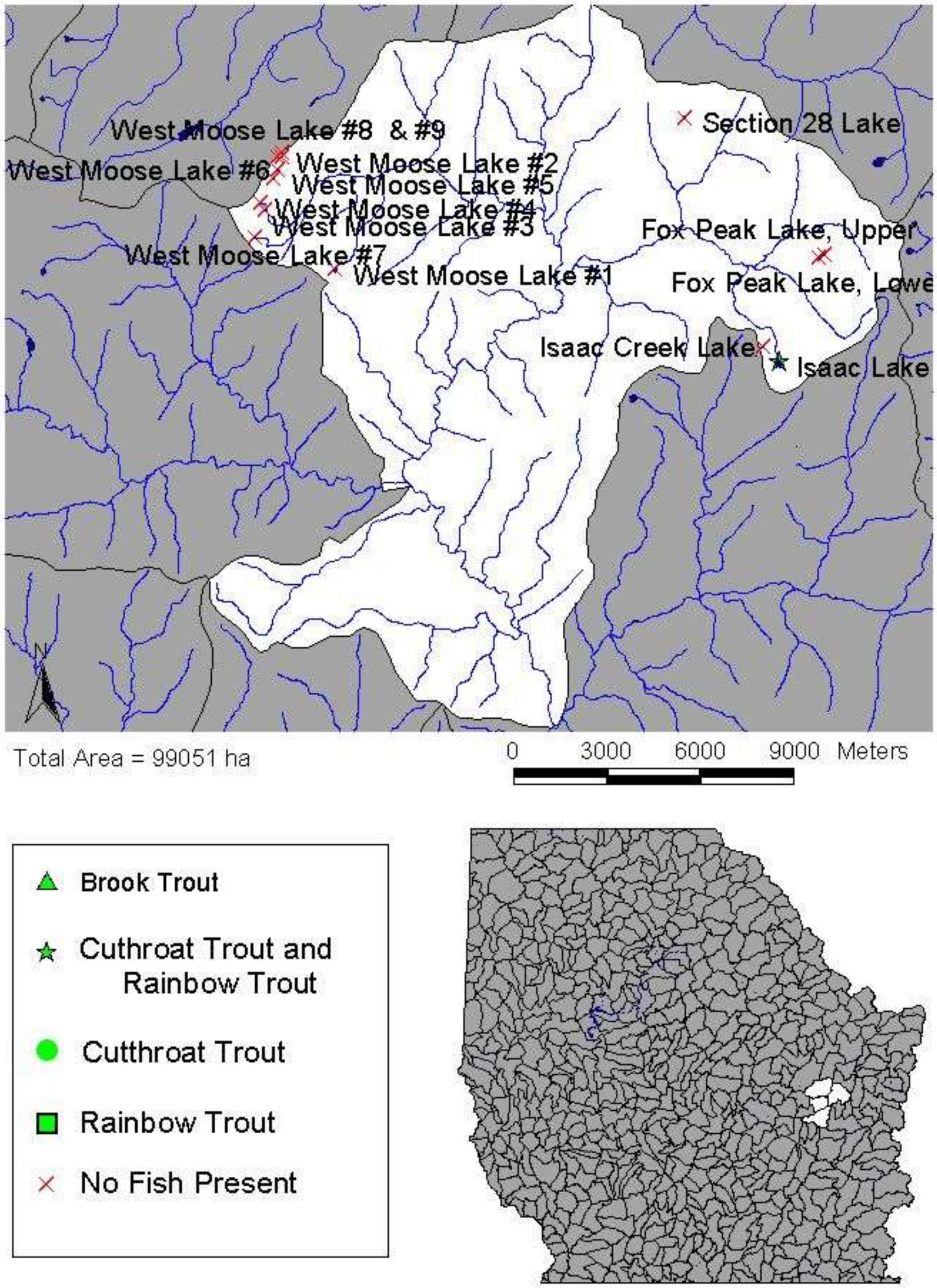
APPENDICES

Appendix A. HUC5 watershed mountain lakes management areas surveyed in 2009 within the Clearwater Region, including historical (before 2006) fish status within these lakes.



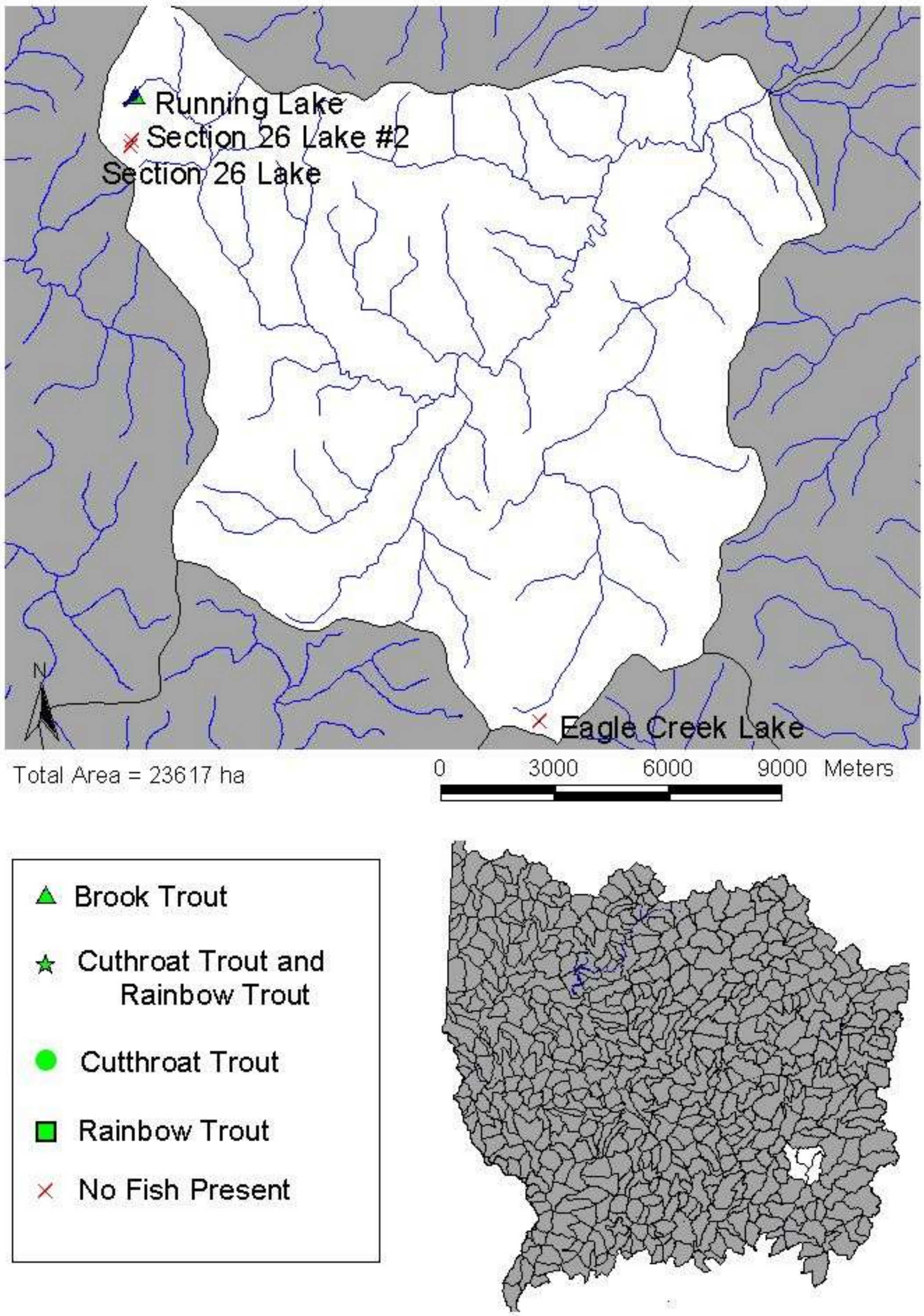
Bargamin Creek (Nez Perce National Forest) Historical Fish Status

Appendix A. Continued.



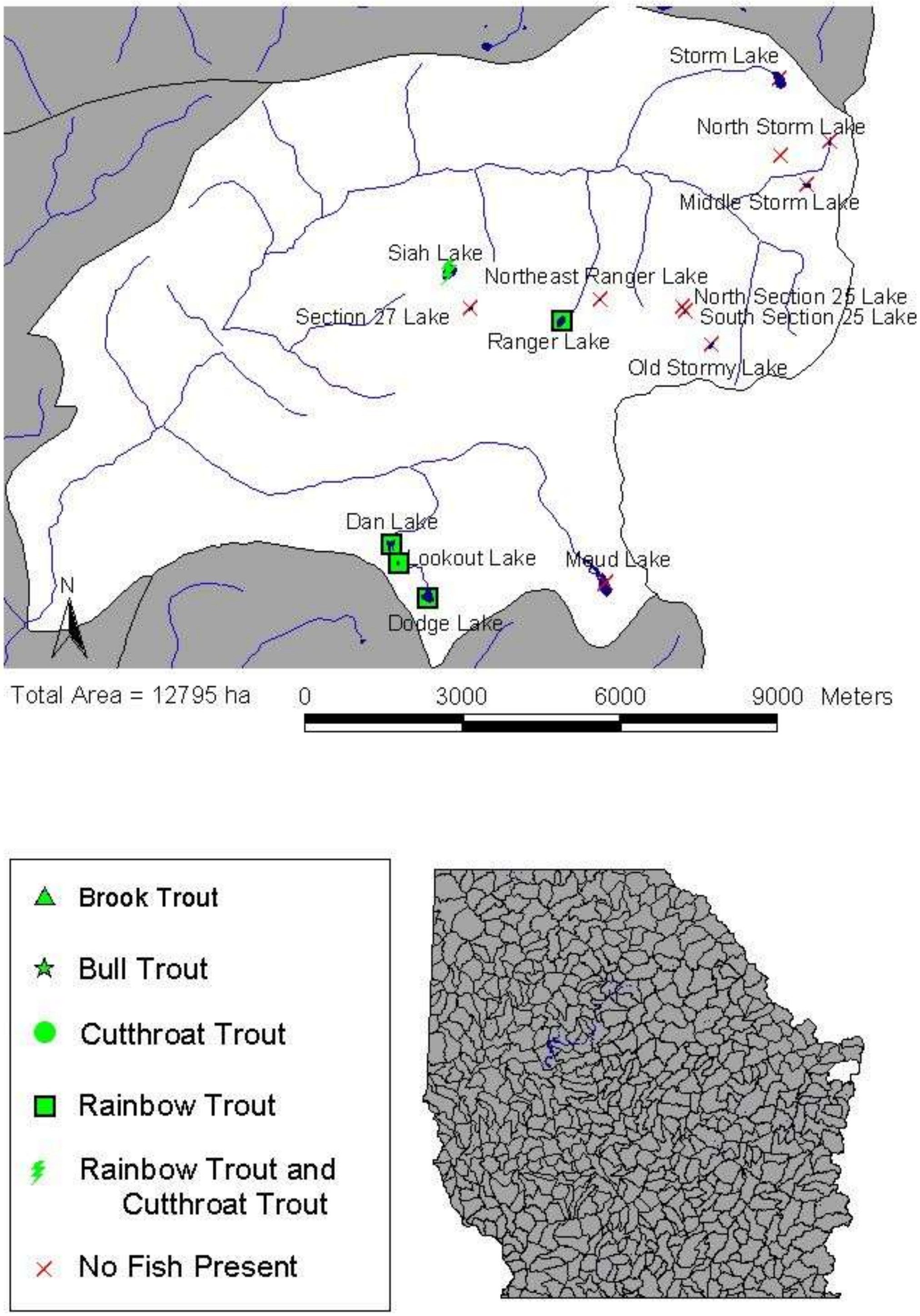
North Fork Moose Creek (Nez Perce National Forest) Historical Fish Status

Appendix A. Continued.



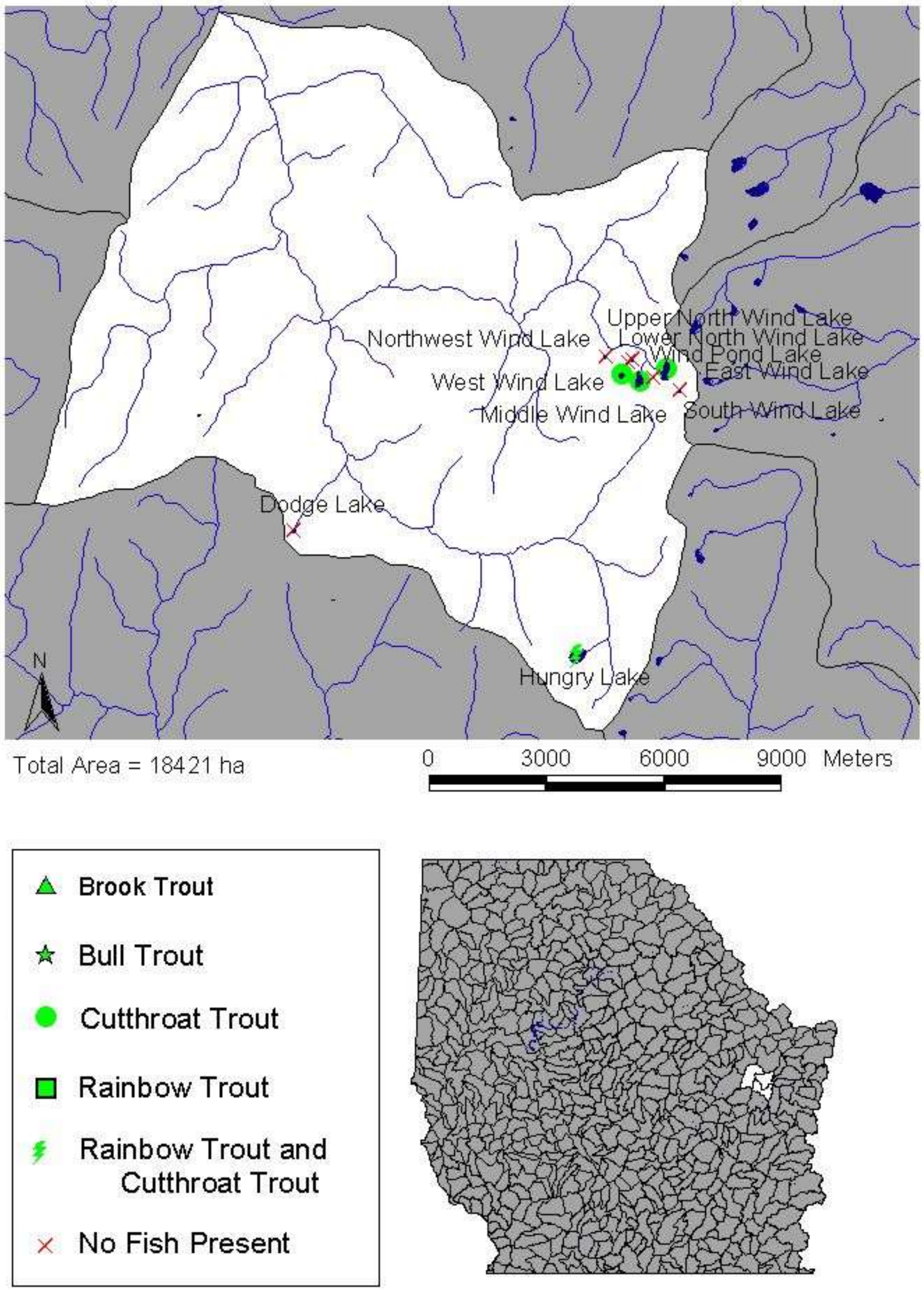
Running Creek (Nez Perce National Forest) Historical Fish Status

Appendix A.   Continued



Storm Creek (Clearwater National Forest) Historical Fish Status

Appendix A. Continued.



Warm Springs Creek (Clearwater National Forest) Historical Fish Status

Appendix B. General characteristics of lakes selected for mountain lakes monitoring project, survey dates (monitoring – 2006 to 2009), fish and amphibian species observations of monitoring survey, and changes in species observations from historic inventory date to round one monitoring date.

Lake name	HUC5 watershed / Amphibian risk classification	Round one monitoring survey date	Longitude (datum WGS 84, format decimal degrees)	Latitude (datum WGS 84, format decimal degrees)	Size (ha)	Max. depth (m)	Elevation (m)	Fish species observed	Amphibian species observed	Change in species observed
Bilk Mountain	Goat/Control	8/18/06	115.0380	45.9396	0.18	<0.5	2113	NONE	CSF/LTS	NEW LTS
Goat	Goat/Control	N/A	115.0040	45.9650	0.36	1.9	2182	NONE	CSF	N/A
Mud	Goat/Control	8/17/06	114.9856	45.9354	0.42	0.9	1889	NONE	CSF/LTS	NONE
Bilk	Up.Meadow/Control	N/A	115.0498	45.9370	0.85	4.0	2054	NONE	CSF	N/A
Elk	Up.Meadow/Control	N/A	115.0783	45.8430	0.67	N/A	2029	NONE	N/A	N/A
Section 27	Up.Meadow/Control	N/A	115.0732	45.9117	0.12	N/A	2100	NONE	N/A	N/A
Fox Peak Lower	N.F. Moose/Low	7/10/06	114.7875	46.3000	0.49	3.7	2017	NONE	CSF	NO LTS
Fox Peak Upper	N.F. Moose/Low	7/10/06	114.7896	46.2991	0.49	3.8	2032	NONE	CSF	NO LTS
Isaac Creek	N.F. Moose/Low	7/09/06	114.8122	46.2735	0.44	0.8	1912	NONE	CSF	N/A
Isaac	N.F. Moose/Low	7/07/06	114.8058	46.2692	5.43	4.8	1901	CT/RBT	CSF	NONE
Section 28	N.F. Moose/Low	7/20/09	114.8461	46.3386	0.50	1.3	2074	NONE	CSF/LTS	NONE
West Moose #1	N.F. Moose/Low	8/07/06	114.9899	46.2940	1.10	3.1	2130	NONE	CSF/LTS	N/A
West Moose #2	N.F. Moose/Low	8/05/06	115.0141	46.3260	0.11	<1.0	2169	NONE	CSF	N/A
West Moose #3	N.F. Moose/Low	8/03/06	115.0191	46.3108	0.41	<1.0	2091	NONE	CSF/LTS	N/A
West Moose #4	N.F. Moose/Low	8/04/06	115.0210	46.3129	0.51	<1.0	2162	NONE	CSF/LTS	N/A
West Moose #5	N.F. Moose/Low	8/04/06	115.0157	46.3199	0.54	1.9	2096	NONE	CSF/LTS	N/A
West Moose #6	N.F. Moose/Low	8/05/06	115.0142	46.3223	0.88	2.7	2110	NONE	CSF/LTS	N/A
West Moose #7	N.F. Moose/Low	8/06/06	115.0234	46.3029	0.47	1.7	2173	NONE	CSF/LTS	N/A
West Moose #8	N.F. Moose/Low	8/05/06	115.0127	46.3271	0.07	<1.0	2167	NONE	CSF	N/A
West Moose #9	N.F. Moose/Low	8/05/06	115.0128	46.3258	0.04	<1.0	2158	NONE	CSF	N/A

CT=Cutthroat trout, RBT=Rainbow trout, CSF=Columbia spotted frog, LTS=Long-toed salamander, NO LTS=no long-toed salamander observations, as seen in inventory survey, NEW LTS= new long-toed salamander observations, not seen in inventory survey

Appendix B. Continued

Lake name	HUC5 watershed / Amphibian risk classification	Round one monitoring survey date	Longitude (datum WGS 84, format decimal degrees)	Latitude (datum WGS 84, format decimal degrees)	Size (ha)	Max. depth (m)	Elevation (m)	Fish species observed	Amphibian species observed	Change in species observed
Dan	Storm/Low	8/21/09	114.4577	46.4766	2.16	3.3	2019	RBT	CSF	NONE
Dodge	Storm/Low	N/A	114.4487	46.4677	4.32	7.0	2118	RBT	CSF	N/A
Lookout	Storm/Low	N/A	114.4559	46.4736	0.33	0.6	2051	RBT	CSF	N/A
Maud	Storm/Low	N/A	114.4048	46.4702	9.32	6.0	1969	NONE	CSF/LTS	N/A
Middle Storm	Storm/Low	8/09/09	114.3552	46.5381	1.04	3.3	2081	NONE	CSF	NO LTS
North Sec. 25	Storm/Low	8/10/09	114.3858	46.5173	0.28	<1.0	2134	NONE	CSF	NO LTS
North Storm	Storm/Low	8/09/09	114.3496	46.5456	0.63	2.0	2227	NONE	CSF	NONE
N.E. Ranger	Storm/Low	7/11/07	114.4062	46.5186	0.32	0.3	1999	NONE	CSF	NO LTS
Old Stormy	Storm/Low	N/A	114.3787	46.5109	0.88	1.5	2210	NONE	CSF/LTS	N/A
Ranger	Storm/Low	7/10/07	114.4160	46.5149	2.74	3.7	1999	RBT	NONE	NO CSF
Section 27	Storm/Low	7/09/07	114.4383	46.5168	0.47	1.2	1999	NONE	CSF	NO LTS
Siah	Storm/Low	7/08/07	114.4437	46.5232	5.26	21.0	1963	RBT/CT	CSF	NONE
South Sec. 25	Storm/Low	8/10/09	114.3853	46.5165	0.20	<1.0	2134	NONE	CSF	LTS
Storm	Storm/Low	2/21/07	114.3623	46.5562	5.42	11.0	1992	NONE	NONE	NO CSF/LTS
Eagle Creek	Running/Moderate	9/07/09	114.9068	45.7695	0.00	Dry	2222	NONE	NONE	N/A
Running	Running/Moderate	7/25/08	115.0463	45.9151	8.37	13.3	2008	BK	NONE	NO CSF
Section 26	Running/Moderate	7/24/08	115.0476	45.9034	0.40	2.0	2087	NONE	NONE	N/A
Section 26 #2	Running/Moderate	7/24/08	115.0468	45.9049	0.17	1.5	2104	NONE	LTS	N/A
Middle Storm	Storm/Low	8/09/09	114.3552	46.5381	1.04	3.3	2081	NONE	CSF	NO LTS
North Sec. 25	Storm/Low	8/10/09	114.3858	46.5173	0.28	<1.0	2134	NONE	CSF	NO LTS
Dodge	Warm Springs/Mod.	7/20/09	114.8593	46.3544	0.89	<1.0	1882	NONE	CSF	NO LTS
East Wind	Warm Springs/Mod.	8/23/08	114.7365	46.3918	7.47	7.6	2167	CT	CSF	NO LTS
Hungry	Warm Springs/Mod.	N/A	114.7652	46.3267	9.95	12.2	2037	CT/RBT	CSF	N/A
Low. N. Wind	Warm Springs/Mod.	8/25/08	114.7492	46.3933	0.22	0.1	2066	NONE	NONE	NO CSF/LTS
Middle Wind	Warm Springs/Mod.	8/24/08	114.7455	46.3889	5.77	8.2	2069	CT*	CSF	NONE
N.W. Wind	Warm Springs/Mod.	7/17/09	114.7568	46.3947	0.71	1.5	1945	NONE	CSF/LTS	NONE
South Wind	Warm Springs/Mod.	8/23/08	114.7319	46.3871	0.78	2.5	2263	NONE	CSF/LTS	NONE
Up. N. Wind	Warm Springs/Mod.	8/25/08	114.7477	46.3940	0.59	0.5	2066	NONE	CSF/LTS	NO CSF
West Wind	Warm Springs/Mod.	8/25/08	114.7514	46.3905	1.99	7.0	2072	CT*	CSF	NONE
Wind Pond	Warm Springs/Mod.	8/23/08	114.7407	46.3901	0.26	2.5	2158	NONE	CSF/LTS	NONE

BK=Brook trout, CT=Cutthroat trout, RBT=Rainbow trout, CSF=Columbia spotted frog, LTS=Long-toed salamander, NO CFS=no Columbia Spotted frog, as seen in inventory survey, NO LTS=no long-toed salamander observations, as seen in inventory survey, NO CFS/LTS=no Columbia Spotted frog or long-toed salamander observations, as seen in inventory survey, NO CFS=no Columbia Spotted frog, as seen in inventory survey, *=fish surveys conducted in 2009

Appendix B. Continued

Lake name	HUC5 watershed / Amphibian risk classification	Round one monitoring survey date	Longitude (datum WGS 84, format decimal degrees)	Latitude (datum WGS 84, format decimal degrees)	Size (ha)	Max. depth (m)	Elevation (m)	Fish species observed	Amphibian species observed	Change in species observed
Bleak Creek	Bargamin/Elevated	N/A	115.0231	45.6513	0.53	4.9	2196	NONE	CSF/LTS	N/A
Boston Mtn.	Bargamin/Elevated	N/A	115.1813	45.6418	0.81	5.2	2329	CT	CSF/LTS	N/A
Goat Lake	Bargamin/Elevated	N/A	115.0931	45.5954	0.93	3.1	2280	CT	LTS	N/A
Lake Creek E.	Bargamin/Elevated	N/A	115.0577	45.6111	1.58	4.8	2182	CT/RBT/X	CSF	N/A
Lake Crk. S.	Bargamin/Elevated	N/A	115.0622	45.6057	8.05	14.8	2231	CT/RBT	CSF	N/A
Lake Creek W.	Bargamin/Elevated	N/A	115.0647	45.6094	3.48	5.0	2182	RBT	CSF	N/A
MacArther	Bargamin/Elevated	7/27/08	114.9754	45.7206	1.98	3.2	2107	CT/RBT	CSF	NO LTS
Stillman	Bargamin/Elevated	7/28/08	114.9923	45.7126	1.17	13.3	2093	CT	CSF/LTS	NEW LTS
Three Prong	Bargamin/Elevated	9/06/09	114.9333	45.7706	0.99	2.7	2192	NONE	CSF/IGS	N/A
Chimney	Old Man/Elevated	N/A	115.2959	46.1968	2.32	6.0	1864	BK	NONE	N/A
Dishpan	Old Man/Elevated	N/A	115.2170	46.1974	1.99	2.5	1878	BK	CSF	N/A
Elizabeth	Old Man/Elevated	N/A	115.2094	46.1989	11.87	11+	1789	BK/CT	CSF	N/A
Flea	Old Man/Elevated	N/A	115.2955	46.2051	1.52	2.0	1851	NONE	CSF	N/A
Florence	Old Man/Elevated	7/22/06	115.2159	46.1778	12.09	7.8	1917	CT	CSF/LTS	NONE
Hjort	Old Man/Elevated	N/A	115.2096	46.1828	0.50	3.5	1902	BK	CSF	N/A
Kettle	Old Man/Elevated	N/A	115.2319	46.1932	5.50	14.9	2176	RBT	CSF/LTS	N/A
Lloyd	Old Man/Elevated	N/A	115.2175	46.1896	9.32	5.0	1892	BK	NONE	N/A
Lottie	Old Man/Elevated	N/A	115.2506	46.2670	3.50	N/A	1873	BK	N/A	N/A
Lottie Upper	Old Man/Elevated	N/A	115.2446	46.2655	2.50	6.1	1888	BK	CSF	N/A
Maude East	Old Man/Elevated	N/A	115.2467	46.2595	1.92	6.2	1938	RBT	CSF	N/A
Maude North	Old Man/Elevated	N/A	115.2511	46.2619	0.80	2.5	1884	NONE	CSF/LTS	N/A
Maude West	Old Man/Elevated	N/A	115.2549	46.2589	2.53	9.8	1853	RBT	CSF	N/A
Old Man	Old Man/Elevated	N/A	115.2382	46.2071	18.58	4.0	1695	BK	CSF	N/A
Wood	Old Man/Elevated	N/A	115.2528	46.2076	0.82	2.4	1929	NONE	CSF/LTS	N/A

BK=Brook trout, CT=Cutthroat trout, RBT=Rainbow trout, X=Rainbow x cutthroat hybrid, CSF=Columbia spotted frog, LTS=Long-toed salamander, NO LTS=no long-toed salamander observations, as seen in inventory survey, NEW LTS= new long-toed salamander observations, not seen in inventory survey, NO CFS/LTS=no Columbia Spotted frog or long-toed salamander observations, as seen in inventory survey

Appendix C. Mountain lakes selected for long term fish and amphibian monitoring with historical amphibian and fish presence data.

Lake name	HUC5 Watershed	Amphibian risk classification	Historical Inventory Date	Fish species observed	Amphibian species observed
Bilk Mountain	Goat	Control	8/10/03	NONE	CSF
Goat	Goat	Control	7/09/86	NONE	CSF
Mud	Goat	Control	8/11/03	NONE	CSF/LTS
Bilk	Upper Meadow	Control	7/11/86	NONE	CSF
Elk	Upper Meadow	Control	N/A	NONE	N/A
Section 27	Upper Meadow	Control	N/A	NONE	N/A
Fox Peak Lower	North Fork Moose	Low	8/28/01	NONE	CSF/LTS
Fox Peak Upper	North Fork Moose	Low	8/28/01	NONE	CSF/LTS
Isaac Creek	North Fork Moose	Low	N/A	NONE	N/A
Isaac	North Fork Moose	Low	8/17/88	CT/RBT	CSF
Section 28	North Fork Moose	Low	8/30/01	NONE	CSF/LTS
West Moose #1	North Fork Moose	Low	N/A	NONE	N/A
West Moose #2	North Fork Moose	Low	N/A	NONE	N/A
West Moose #3	North Fork Moose	Low	N/A	NONE	N/A
West Moose #4	North Fork Moose	Low	N/A	NONE	N/A
West Moose #5	North Fork Moose	Low	N/A	NONE	N/A
West Moose #6	North Fork Moose	Low	N/A	NONE	N/A
West Moose #7	North Fork Moose	Low	N/A	NONE	N/A
West Moose #8	North Fork Moose	Low	N/A	NONE	N/A
West Moose #9	North Fork Moose	Low	N/A	NONE	N/A
Dan	Storm	Low	8/21/1991	RBT	CSF
Dodge	Storm	Low	8/20/1991	RBT	CSF
Lookout	Storm	Low	7/30/1996	RBT	CSF
Maud	Storm	Low	8/22/1991	NONE	CSF/LTS
Middle Storm	Storm	Low	8/22/1997	NONE	CSF/LTS
North Section 25	Storm	Low	9/10/1996	NONE	CSF/LTS
North Storm	Storm	Low	8/22/1997	NONE	CSF
N.E. Ranger	Storm	Low	9/10/1996	NONE	CSF/LTS
Old Stormy	Storm	Low	9/10/1996	NONE	CSF/LTS
Ranger	Storm	Low	9/09/1996	RBT	CSF
Section 27	Storm	Low	9/08/1996	NONE	CSF/LTS
Siah	Storm	Low	9/09/1996	RBT/CT	CSF
South Section 25	Storm	Low	9/10/1996	NONE	CSF/LTS
Storm	Storm	Low	8/21/1997	NONE	CSF/LTS
Eagle Creek	Running	Moderate	N/A	NONE	N/A
Running	Running	Moderate	8/15/01	BK	CSF
Section 26	Running	Moderate	N/A	NONE	N/A
Section 26 #2	Running	Moderate	N/A	NONE	N/A
Dodge	Warm Springs	Moderate	7/27/1996	NONE	CSF/LTS
East Wind	Warm Springs	Moderate	8/11/1995	CT	CSF/LTS
Hungry	Warm Springs	Moderate	7/8/1991	CT/RBT	CSF
Low. North Wind	Warm Springs	Moderate	7/16/1996	NONE	CSF/LTS
Middle Wind	Warm Springs	Moderate	8/12/1995	CT	CSF
Northwest Wind	Warm Springs	Moderate	8/12/1995	NONE	CSF/LTS
South Wind	Warm Springs	Moderate	8/11/1995	NONE	CSF/LTS
Up. North Wind	Warm Springs	Moderate	7/16/1996	NONE	LTS
West Wind	Warm Springs	Moderate	8/12/1995	CT	CSF
Wind Pond	Warm Springs	Moderate	8/12/1995	NONE	CSF/LTS

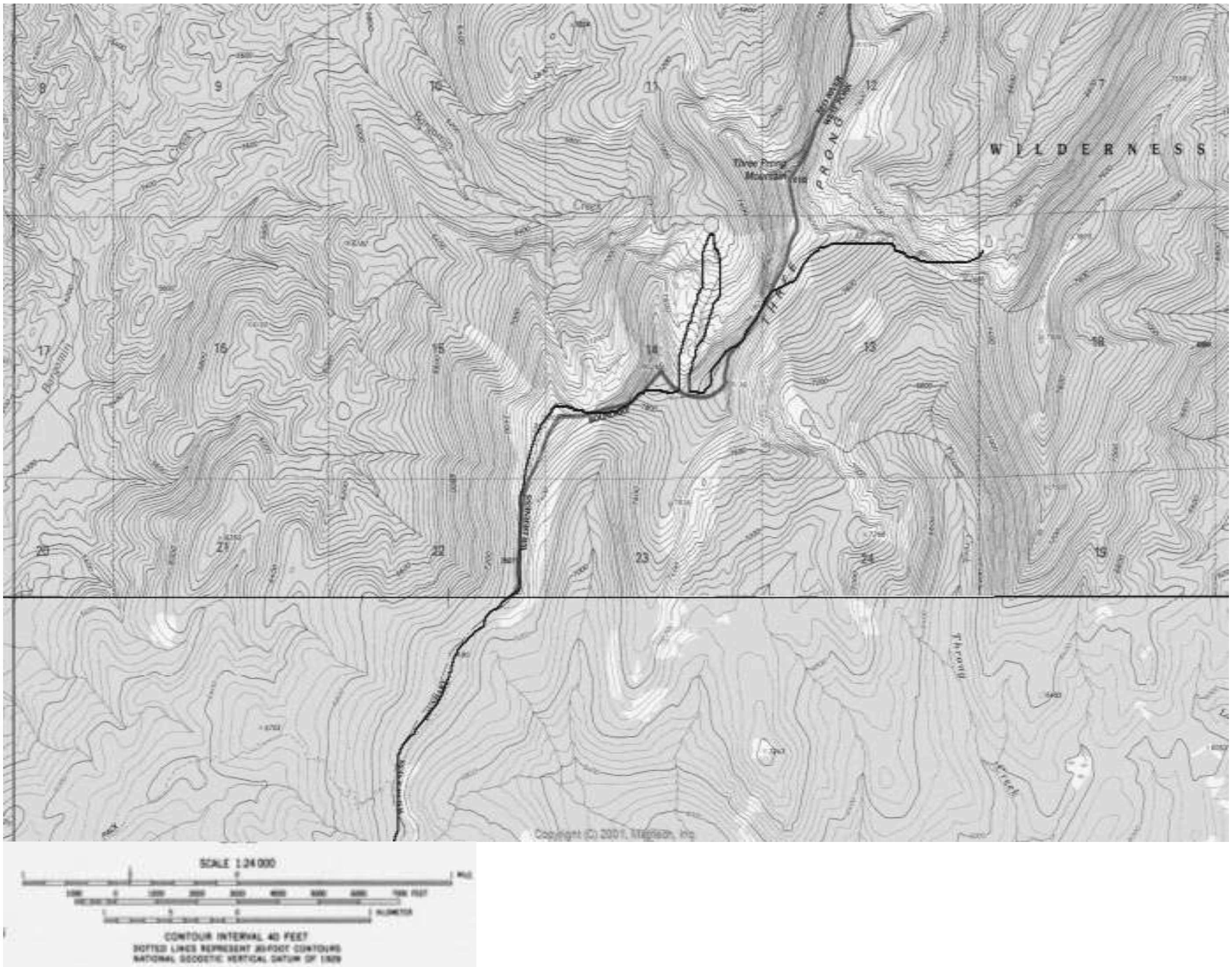
BK=Brook trout, CT=Cutthroat trout, RBT=Rainbow trout, CSF=Columbia spotted frog, LTS=Long-toed salamander

Appendix C. Continued

Lake name	HUC5 Watershed	Amphibian risk classification	Historical Inventory Date	Fish species observed	Amphibian species observed
Bleak Creek	Bargamin	Elevated	7/7/89	NONE	CSF/LTS
Boston Mountain	Bargamin	Elevated	9/7/89	CT	CSF/LTS
Goat Lake	Bargamin	Elevated	6/20/89	CT	LTS
Lake Creek East	Bargamin	Elevated	7/6/89	CT/RBT/X	CSF
Lake Crk. South	Bargamin	Elevated	7/12/89	CT/RBT	CSF
Lake Creek West	Bargamin	Elevated	6/11/89	RBT	CSF
MacArther	Bargamin	Elevated	8/5/95	CT/RBT	CSF/LTS
Stillman	Bargamin	Elevated	8/4/95	CT	CSF
Three Prong	Bargamin	Elevated	N/A	NONE	N/A
Chimney	Old Man	Elevated	7/7/1995	BK	NONE
Dishpan	Old Man	Elevated	7/15/1995	BK	CSF
Elizabeth	Old Man	Elevated	7/16/1995	BK/CT	CSF
Flea	Old Man	Elevated	7/13/1995	NONE	CSF
Florence	Old Man	Elevated	7/23/1991	CT	CSF/LTS
Hjort	Old Man	Elevated	7/15/1995	BK	CSF
Kettle	Old Man	Elevated	7/21/1991	RBT	CSF/LTS
Lloyd	Old Man	Elevated	7/15/1995	BK	NONE
Lottie	Old Man	Elevated	N/A	BK	N/A
Lottie Upper	Old Man	Elevated	7/14/1991	BK	CSF
Maude East	Old Man	Elevated	7/16/1991	RBT	CSF
Maude North	Old Man	Elevated	7/17/1991	NONE	CSF/LTS
Maude West	Old Man	Elevated	7/25/1991	RBT	CSF
Old Man	Old Man	Elevated	7/14/1995	BK	CSF
Wood	Old Man	Elevated	7/20/1991	NONE	CSF/LTS

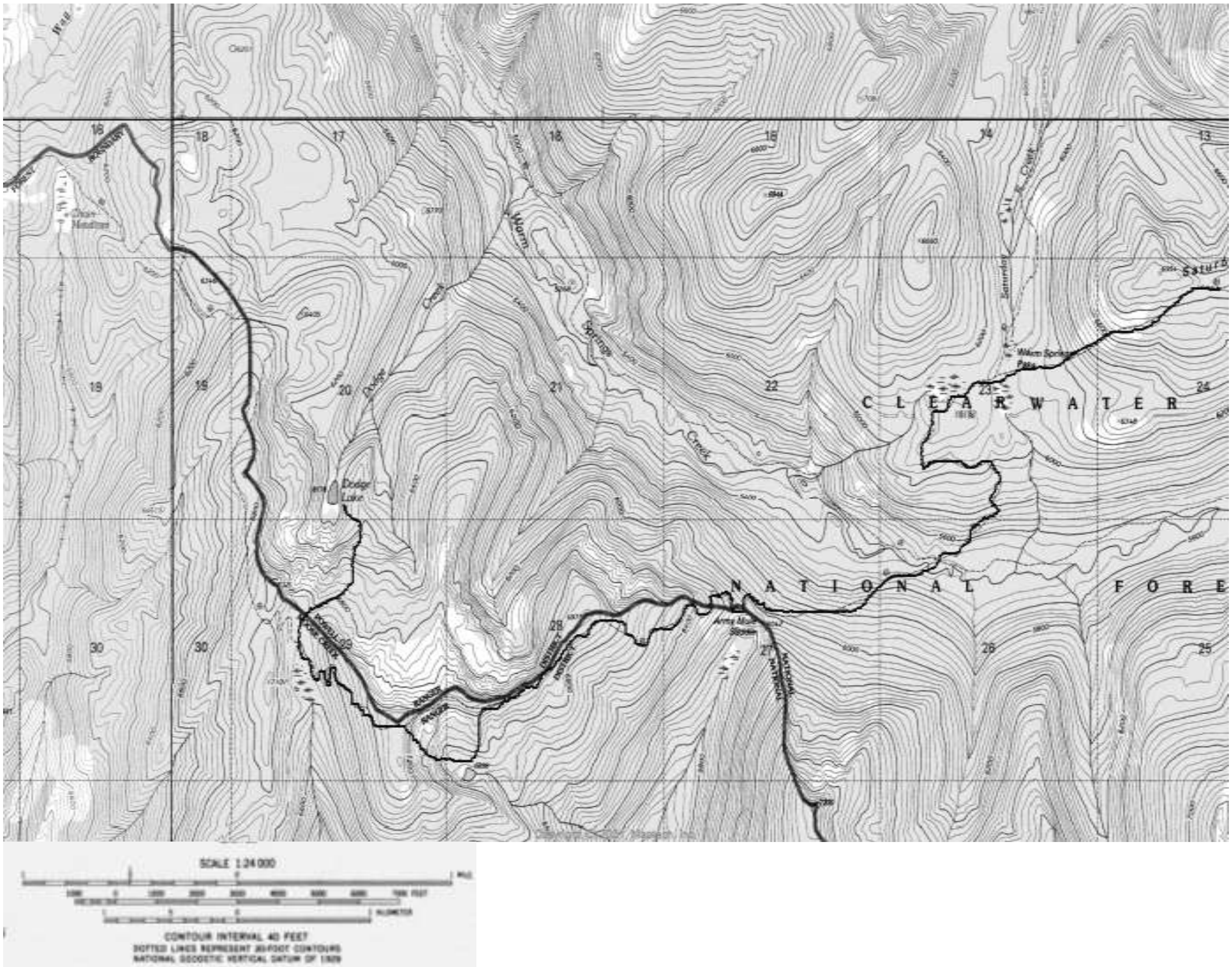
BK=Brook trout, CT=Cutthroat trout, RBT=Rainbow trout, X=Rainbow x cutthroat hybrid
CSF=Columbia spotted frog, LTS=Long-toed salamander

Appendix D. Topographic maps of lakes surveyed in 2009 located in the Clearwater Region, and the routes (black line) used to access each lake.



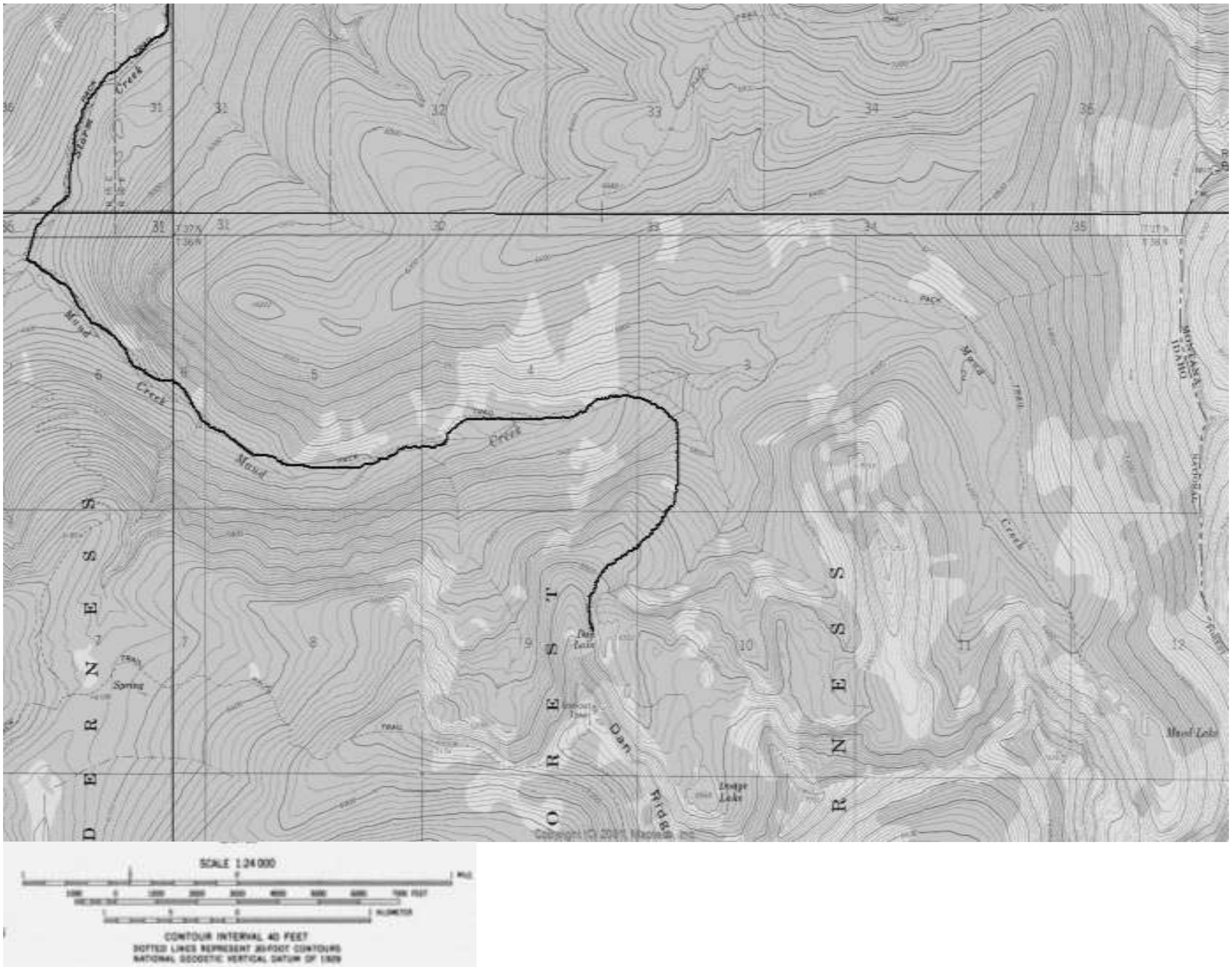
Routes used to access Three Prong Lake within the Bargamin Creek watershed, and Eagle Creek Lake in the Running Creek watershed, Nez Perce National Forest.

Appendix D.   Continued.



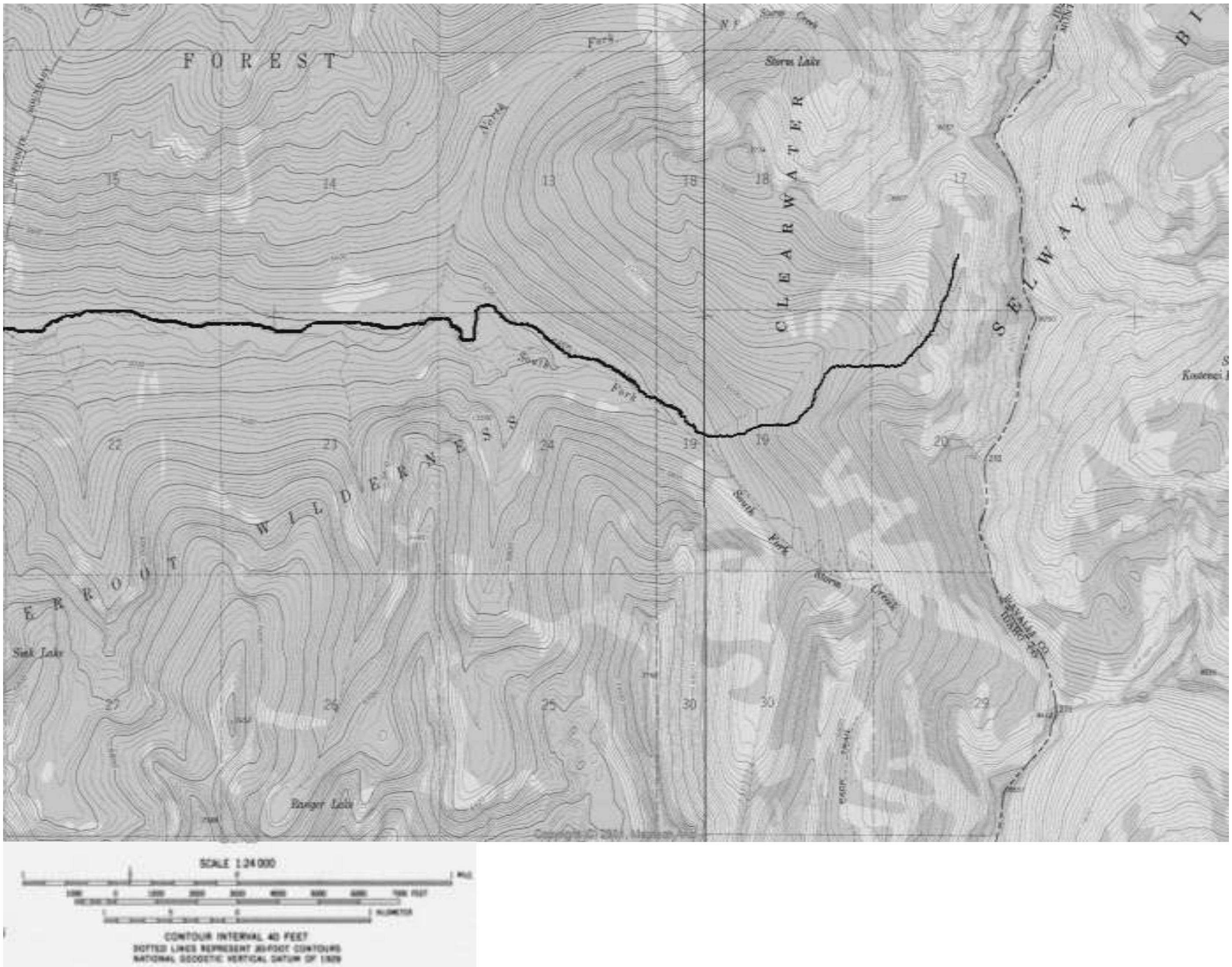
Routes used to access Dodge Lake within the Warm Springs Creek watershed, Clearwater National Forest and Section 28 in the North Fork Moose Creek watershed, Nez Perce National Forest.

Appendix D.   Continued.



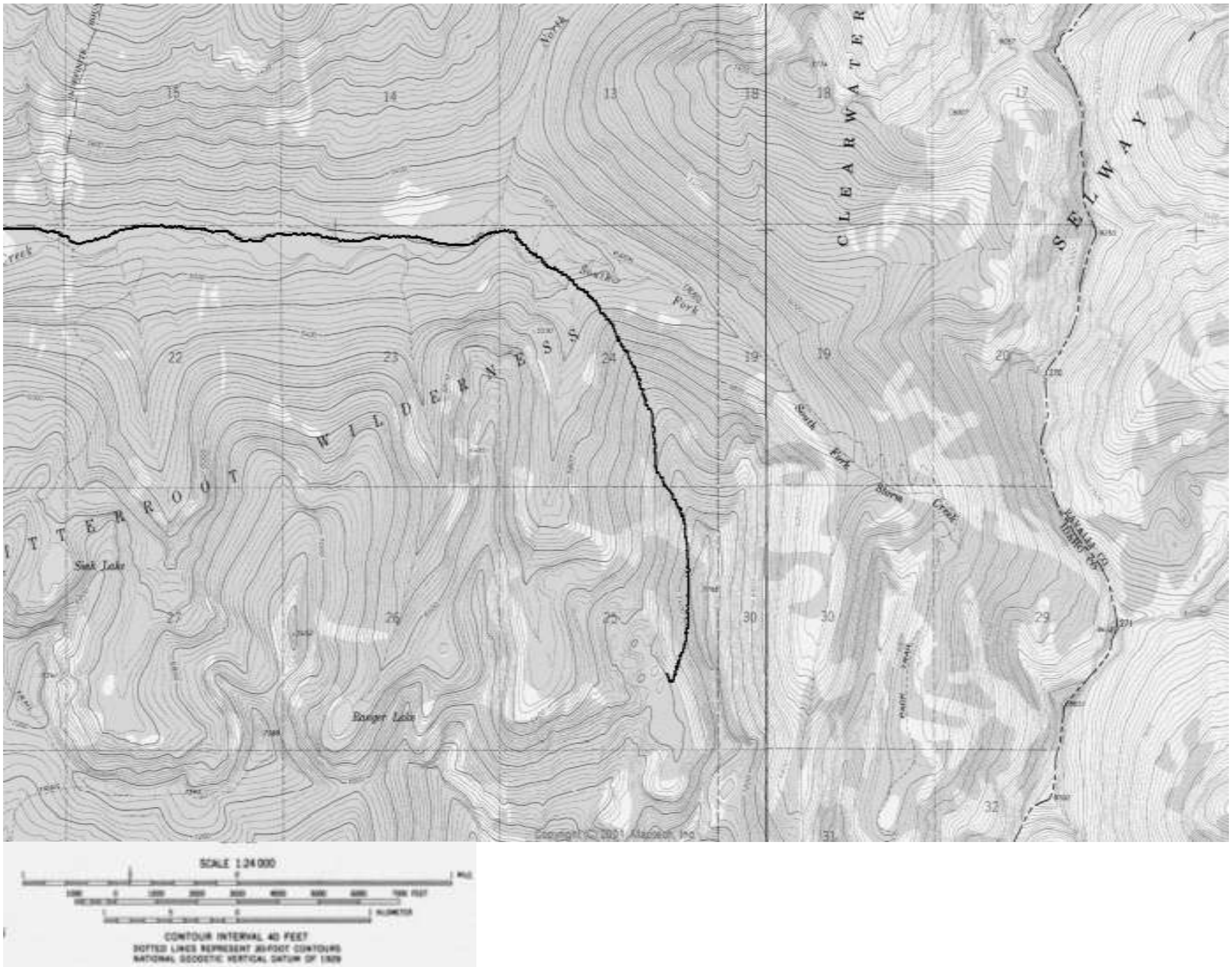
Routes used to access Dan Lake within the Storm Creek watershed, Clearwater National Forest.

Appendix D.   Continued.



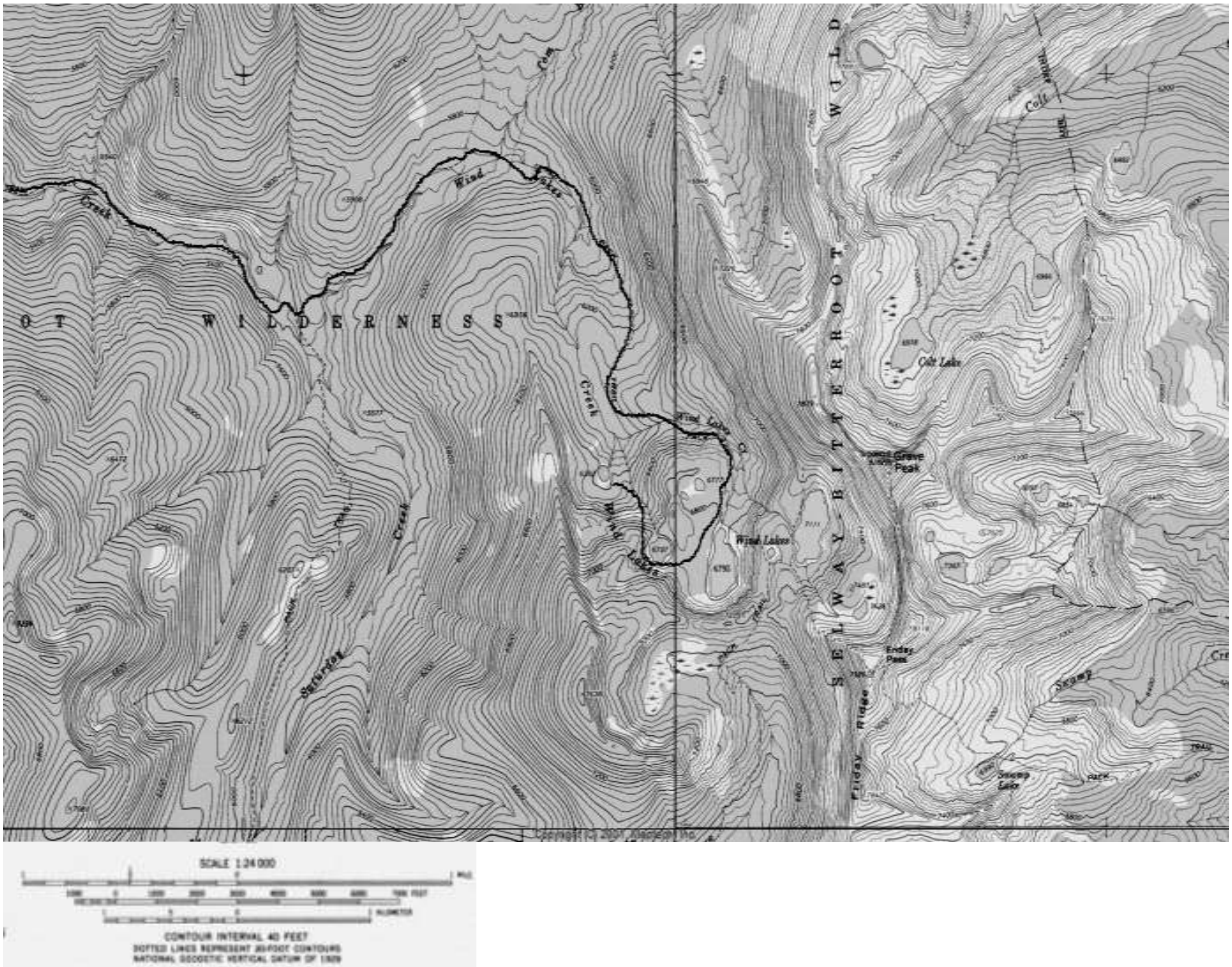
Routes used to access Middle and North Storm Lakes within the Storm Creek watershed, Clearwater National Forest.

Appendix D.   Continued.



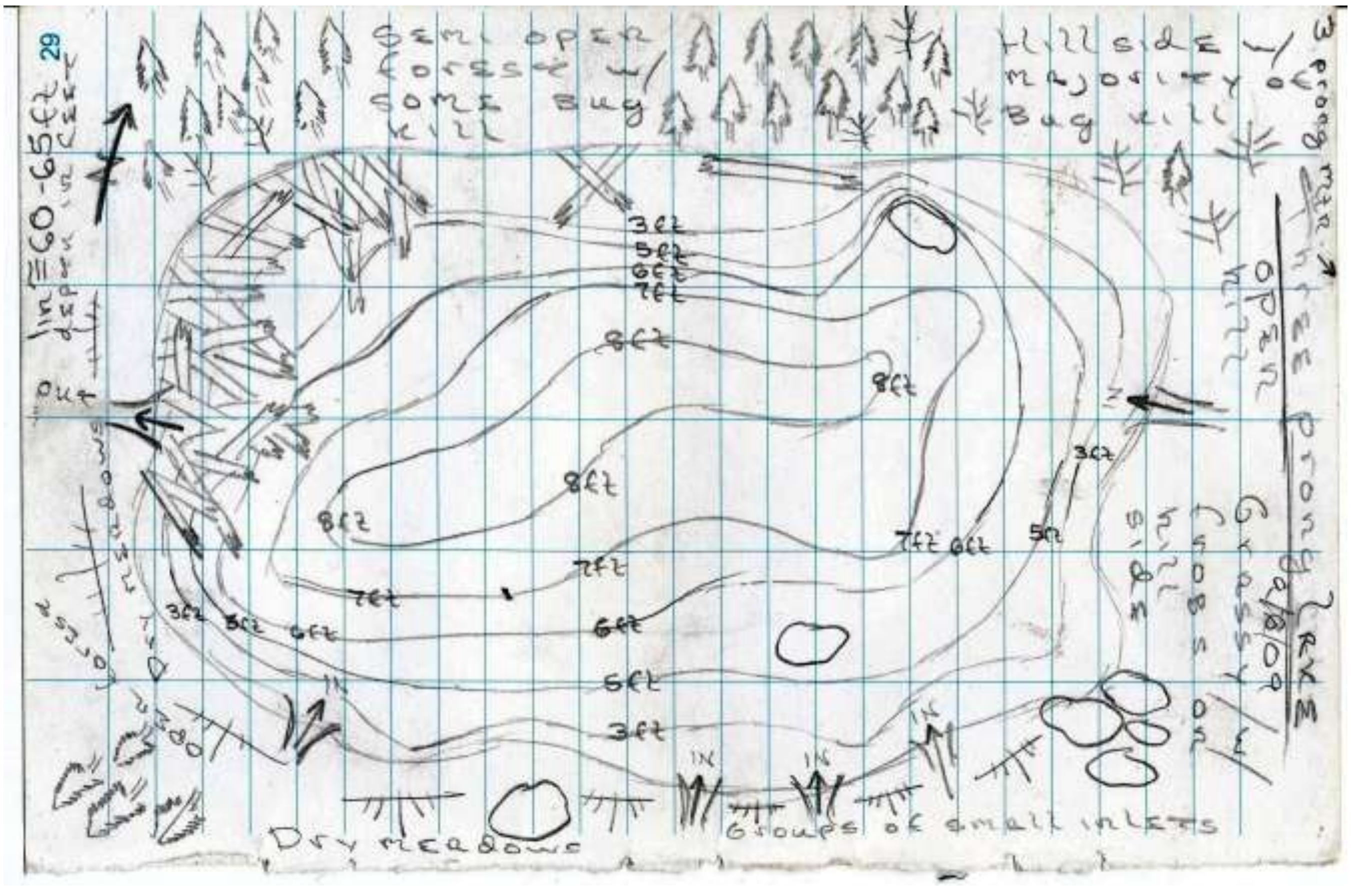
Routes used to access North and South Section 25 Lakes within the Storm Creek watershed, Clearwater National Forest.

Appendix D.   Continued.



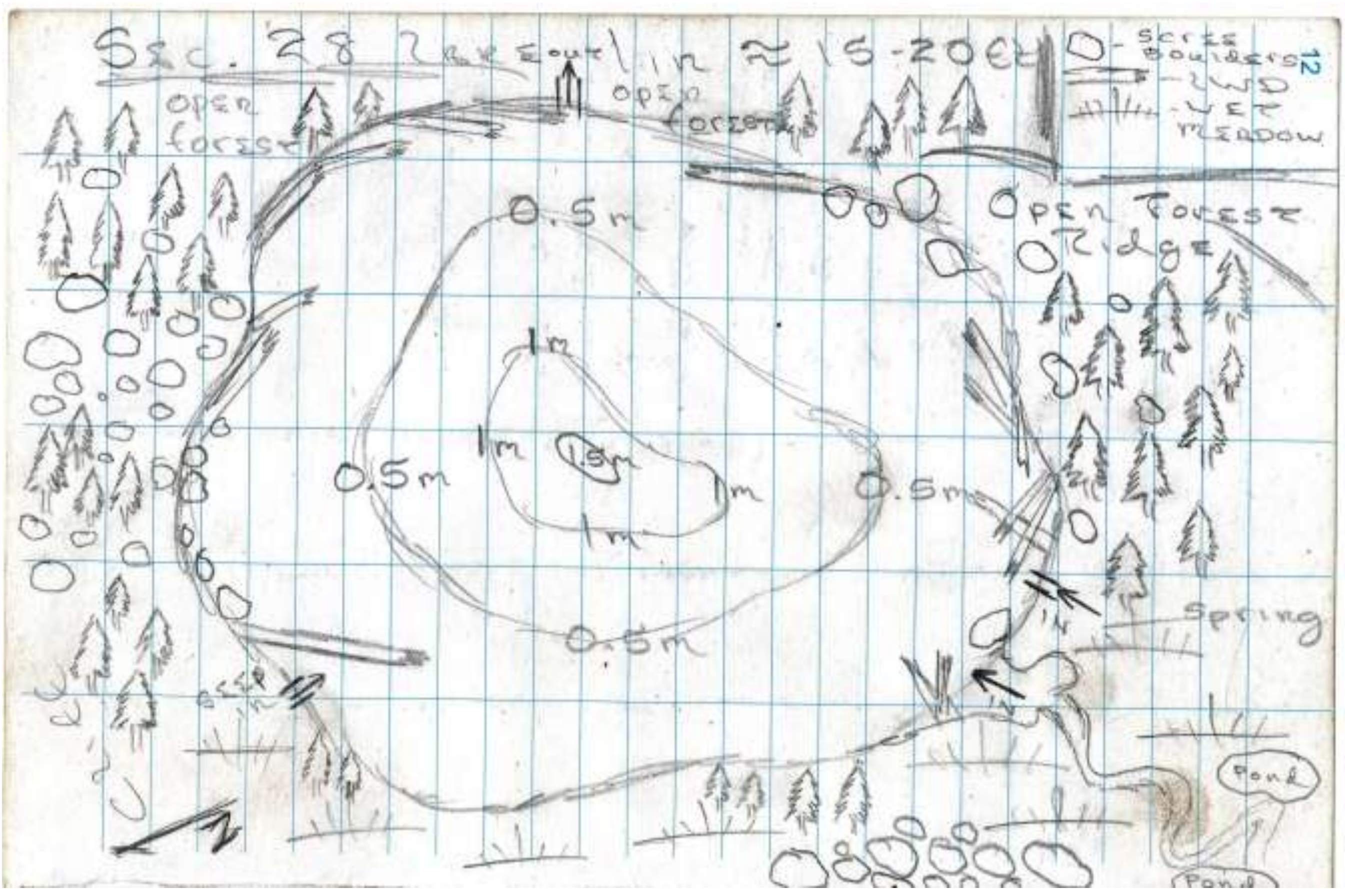
Routes used to access lakes (Middle Wind Lake, West Wind Lake, and Northwest Wind Lake) within the Warm Springs Creek watershed, Clearwater National Forest.

Appendix E. Bathymetry maps and surrounding area maps produced by personnel in the field.



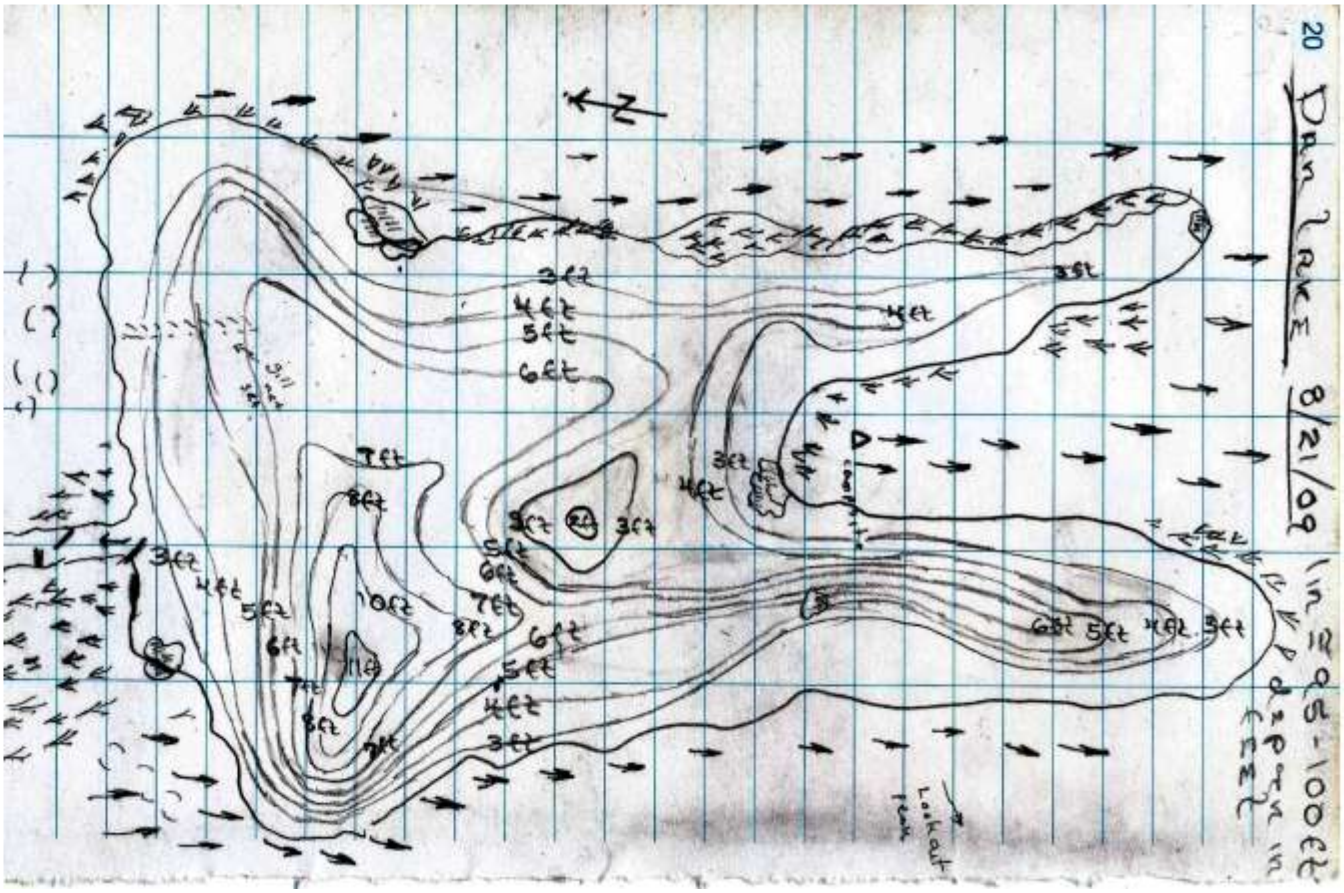
Three Prong Lake from the Bargamin Creek watershed

Appendix E. Continued.



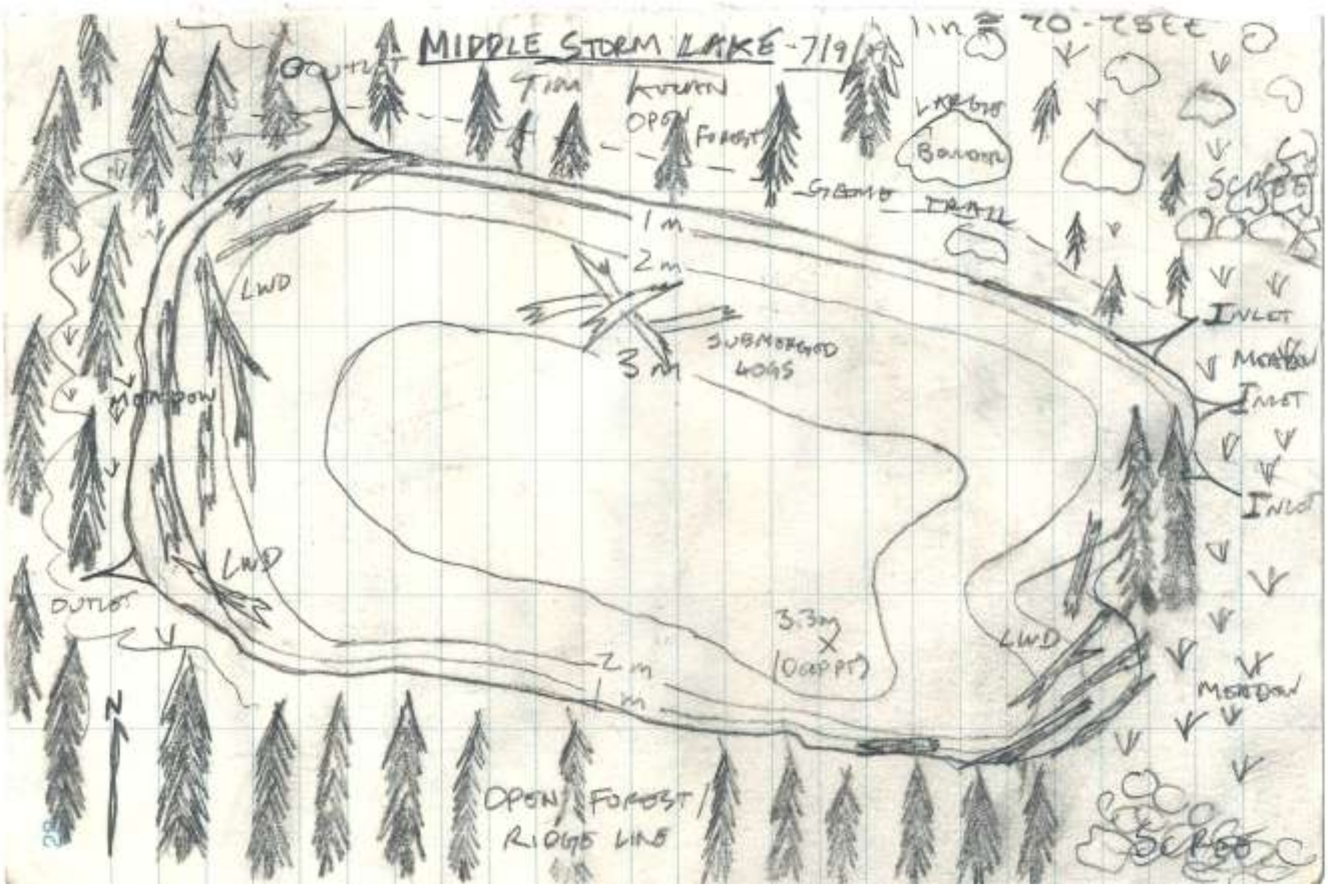
Section 28 Lake from the North Fork Moose Creek watershed

Appendix E. Continued.



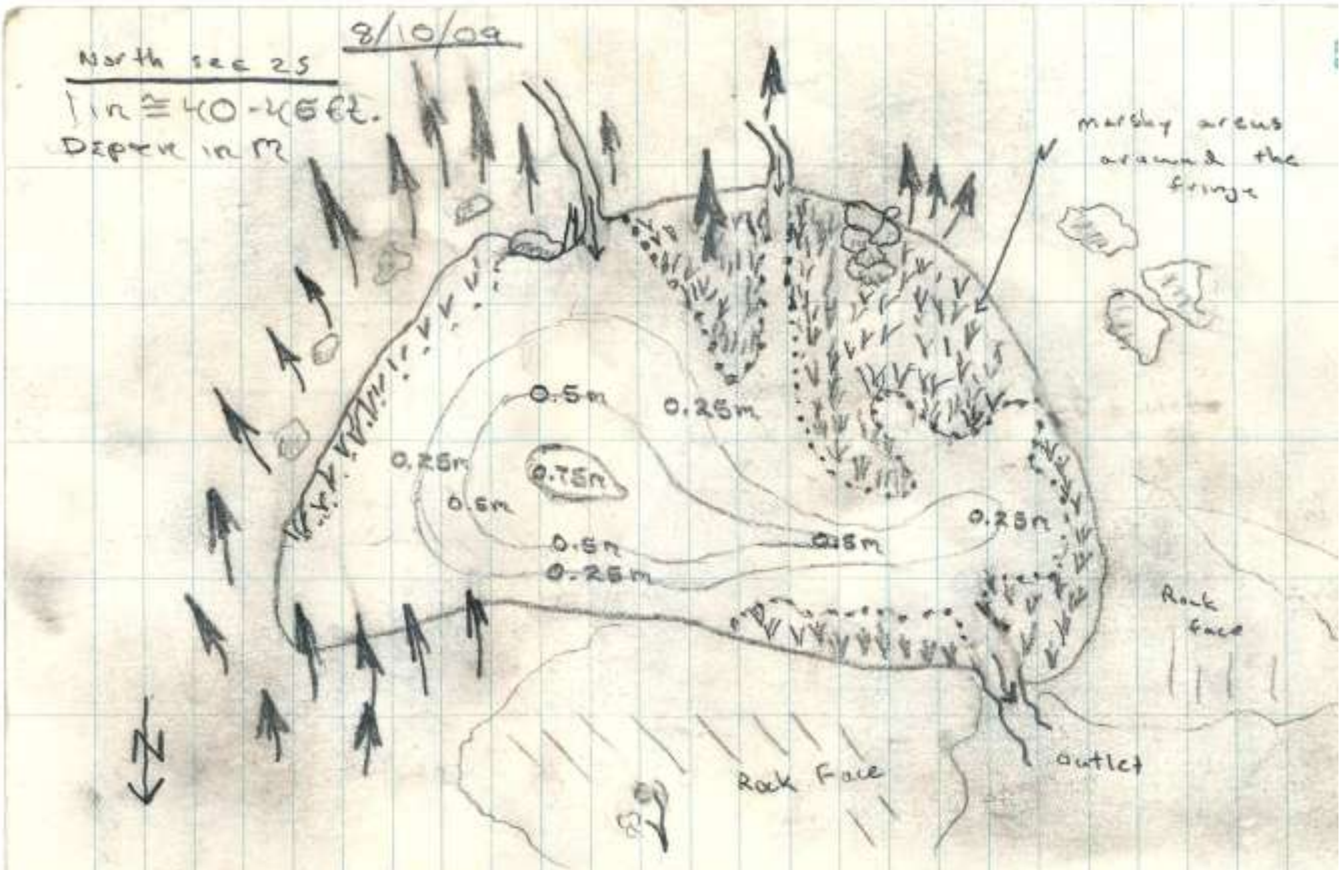
Dan Lake from the Storm Creek watershed

Appendix E. Continued.



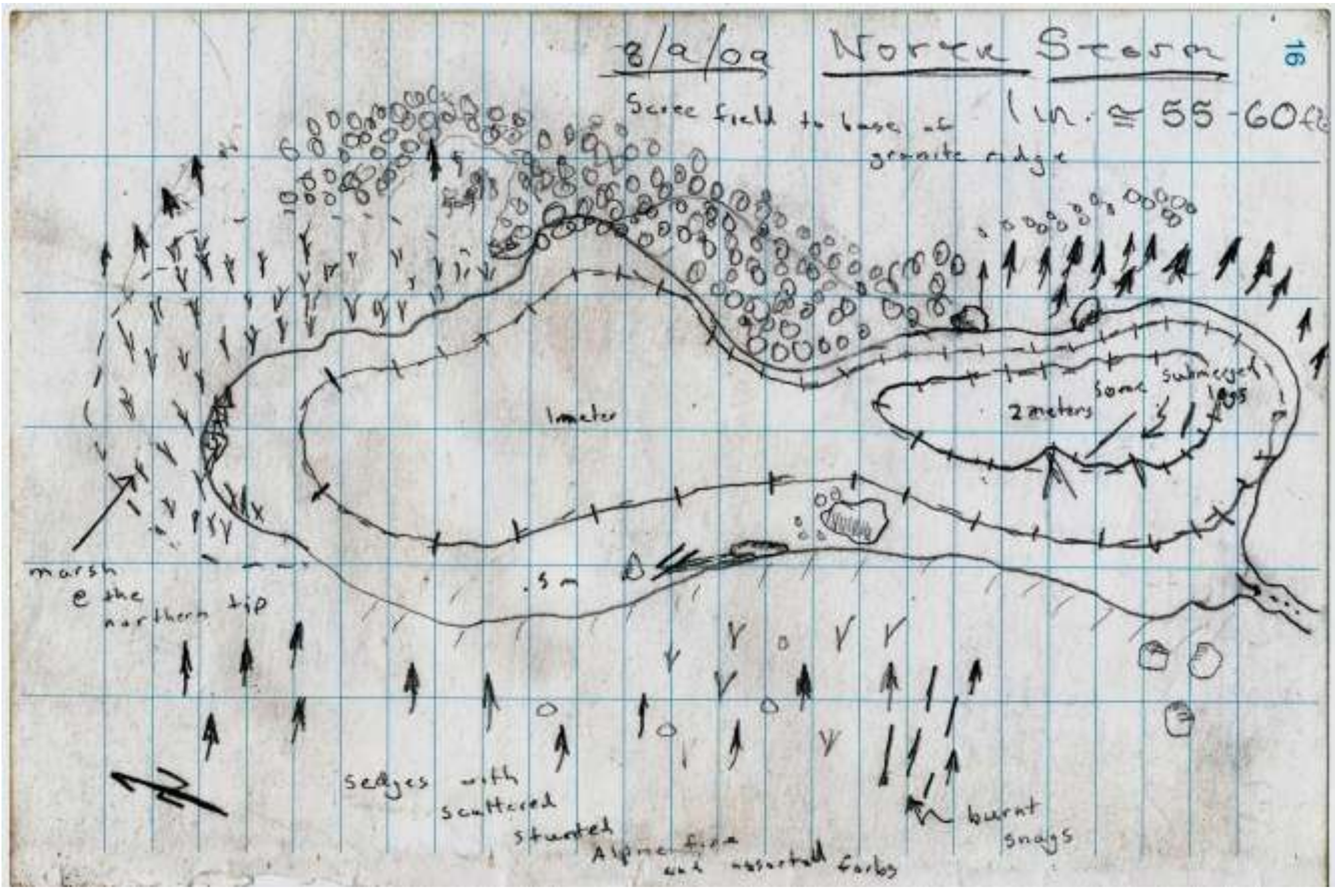
Middle Storm Lake from the Storm Creek watershed

Appendix E.   Continued.



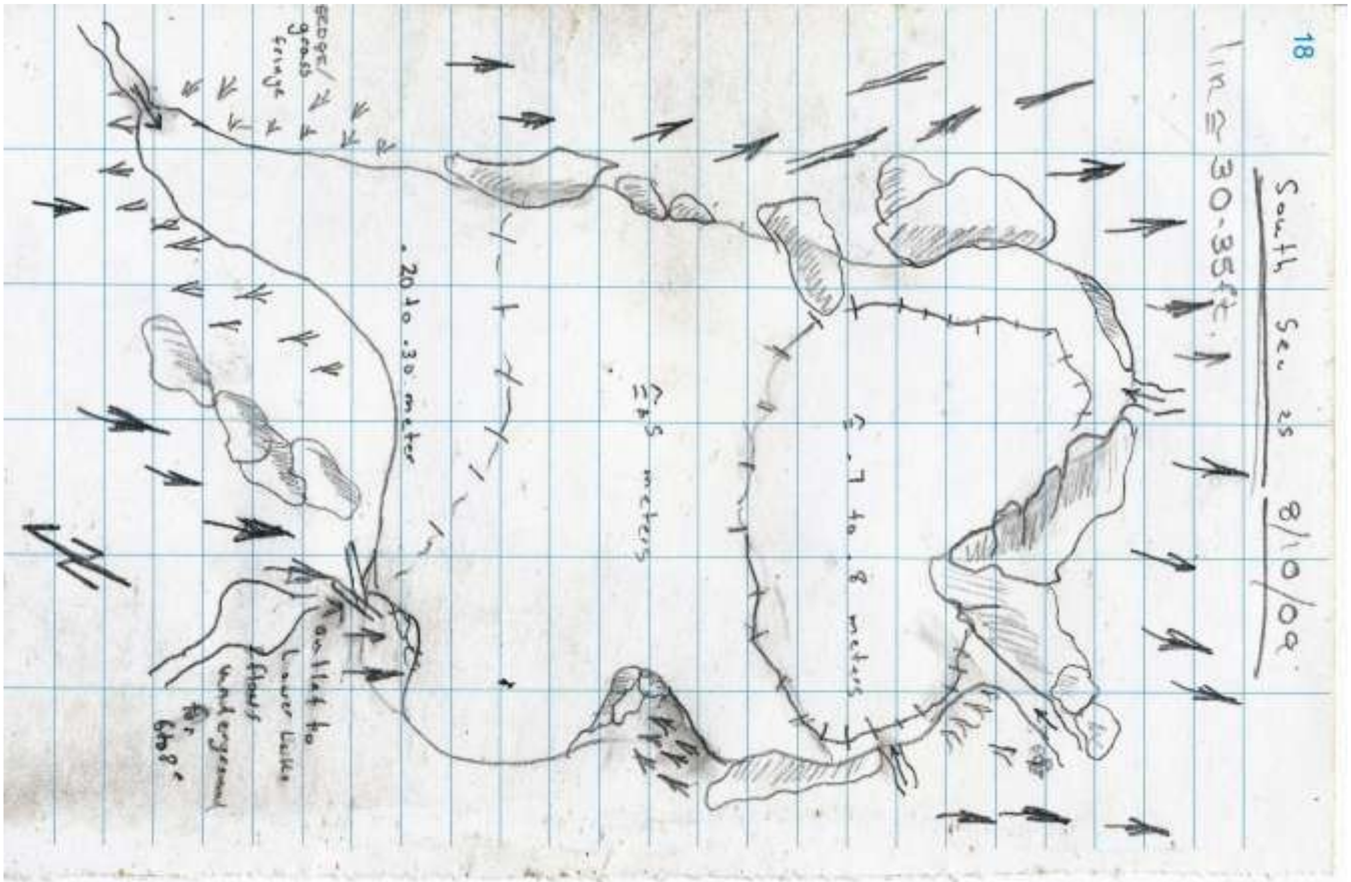
North Section 25 Lake from the Storm Creek watershed

Appendix E. Continued.



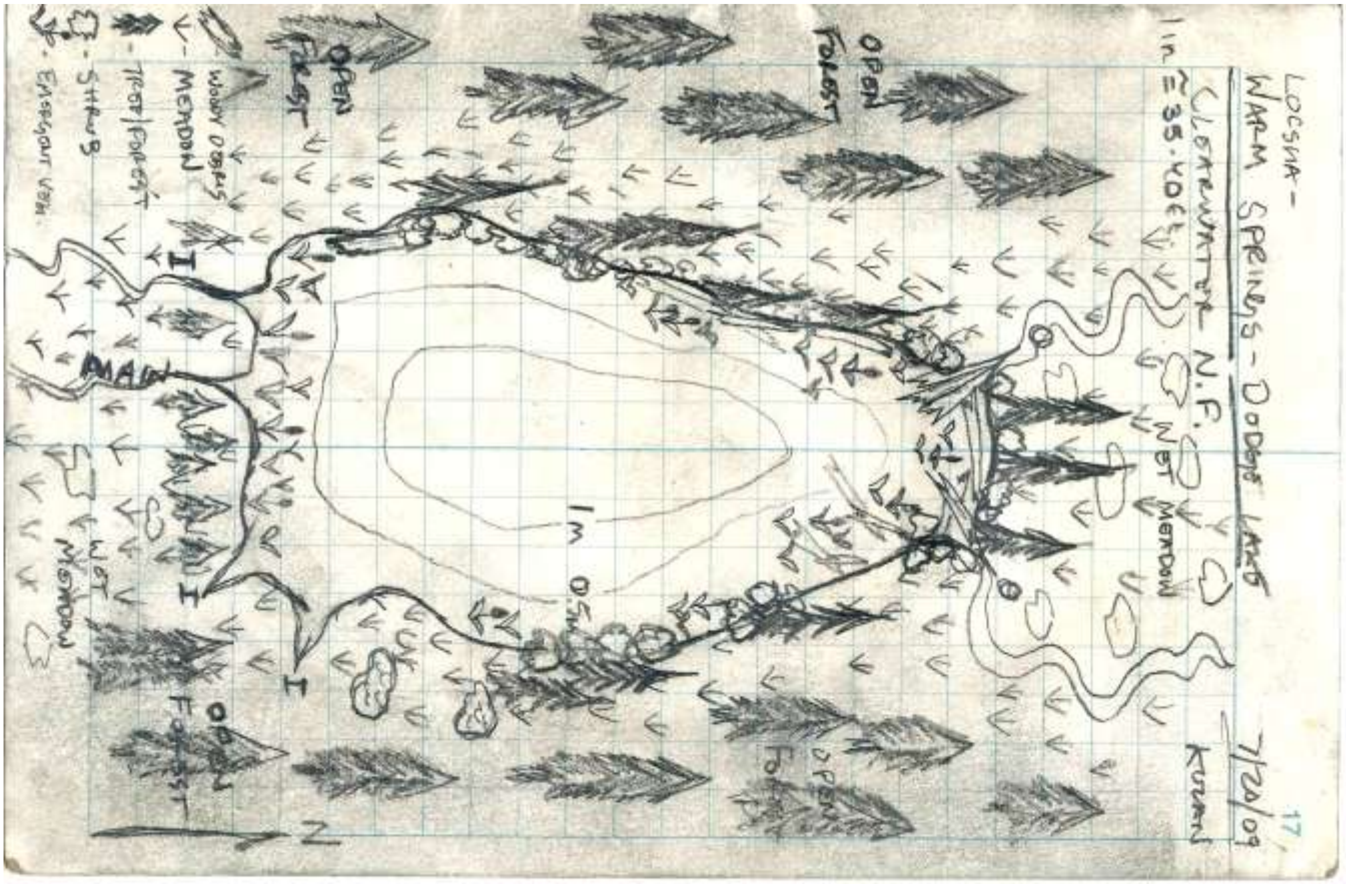
North Storm Lake from the Storm Creek watershed

Appendix E.   Continued.



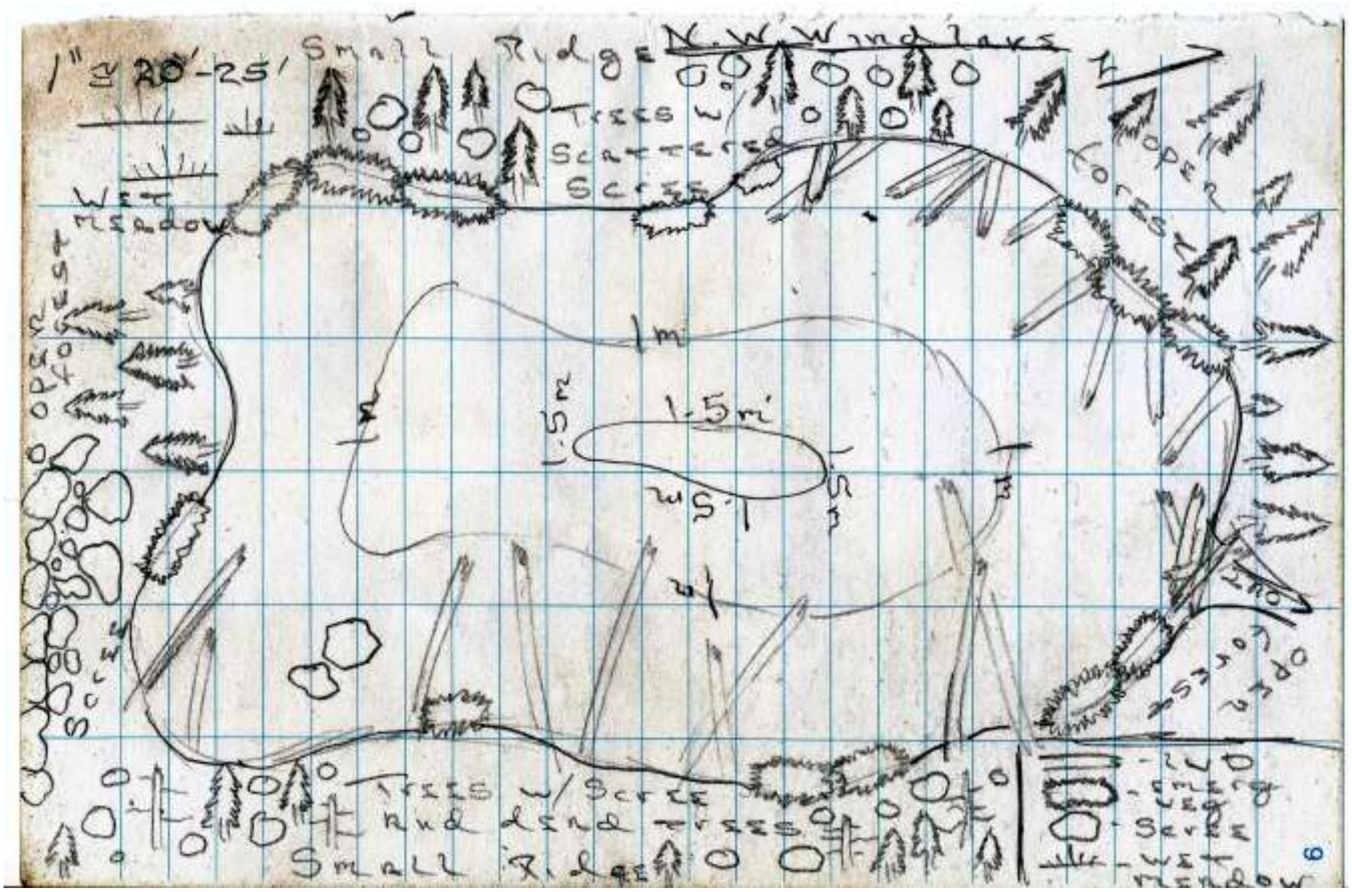
South Section 25 Lake from the Storm Creek watershed

Appendix E.   Continued.



Dodge Lake from the Warm Springs Creek watershed

Appendix E.   Continued.



Northwest Wind Lake from the Warm Springs Creek watershed

Appendix F.   Photographs of high mountain lakes surveyed within the Clearwater Region in 2009.

Three Prong Lake Bargamin Creek watershed

Section 28 Lake North Fork Moose Creek watershed

Appendix F. Continued

Eagle Creek Lake (dry) Running Creek watershed

Middle Storm Lake Storm Creek watershed

Appendix F. Continued.

North Section 25 Lake Storm Creek watershed

North Storm Lake Storm Creek watershed

Appendix F. Continued.

South Section 25 Lake Storm Creek watershed

Dodge Lake Warm Springs Creek watershed

Appendix F. Continued.

Northwest Wind Lake Warm Springs Creek watershed

Appendix G. Clearwater Region mountain lakes data sheet (page 1).

HIGH MOUNTAIN LAKES SURVEY DATA SHEET

Lake Name:	Survey Date (mm-dd-yy)
Drainage:	Legal Description: Township - Range - Section -
County:	Elevation (m)
National Forest – Ranger Distict	Northing (GPS) - Easting (GPS) -
Crew Members:	Topo Map (7.5')
	IDFG Lake #

Lake Description:

HABITAT PARAMETERS

Physical Data	Chemical Data
Surface Area (Hectares) -	Conductivity (μs) -
Aspect -	pH -
Maximum Lake Depth (m) -	Water Temperature (° C) (shallow) -
% Bottom Composition < than 3.0 m deep(littoral) -	Air Temperature (°C) -
Secchi Disc (m) -	Weather -

Littoral zone substrate composition (%)

Bedrock _______ Boulders_______ Rubble_______ Gravel_______ Sand_______ Silt_______ Organic debris_______ Logs_______

Stream Characteristics

Stream	1	2	3	4	5	6	7
Inlet (I) of Outlet (O)							
Width (m)							
Depth (m)							
Water Speed (1 – 4)							
Dominant Substrate							
Barrier Type							
Distance to Barrier							
% Spawning Sub, (Gr,Sa), 1 – 50 m							
Number of fish observed							

Appendix G. (Continued) Mountain lakes data sheet (Page 2).

Forest Cover

% Shore Forest Cover (0-10m) ________ % Open Ground (0- 10 m) ________

Dominant Tree Species and % of each:

Fish Population Data

Fish Species present:

Gill Net – Time and CPUE: ________ Angling – Time and CPUE: ________

Last Year Stocked (Year, Date, Species, Density) -

Number - Species	Length (mm)	Weight (g)	Number - Species	Length (mm)	Weight (g)
1.			11.		
2.			12.		
3.			13.		
4.			14.		
5.			15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

Fish Stomach Content -

Fish Condition -

Zooplankton Samples

Deep Tows (2 tows and Depth (m) of tows) - Shallow Tows (4 tows, 5 m. in length) -

Aquatic Invertebrates

Family and Abundance -

1.	5.
2.	6.
3.	7.
4.	8.

Amphibian Survey (VES)

Survey Description:

Survey Start Time (hhmm) ________ Total Survey Duration - ________

Species	# Adults	# Subadults	# Larvae	# Egg Masses	Comments
Columbia Spotted Frog					
Western Long-toed Salamander					
Tailed Frog					
Common Garter Snake					
Western Terrestrial Garter Snake					

Animal Observations

Species	# Number	Location	Species	# Number	Location
1.			6.		
2.			7.		
3.			8.		
4.			9.		
5.			10.		

Campsite Impacts

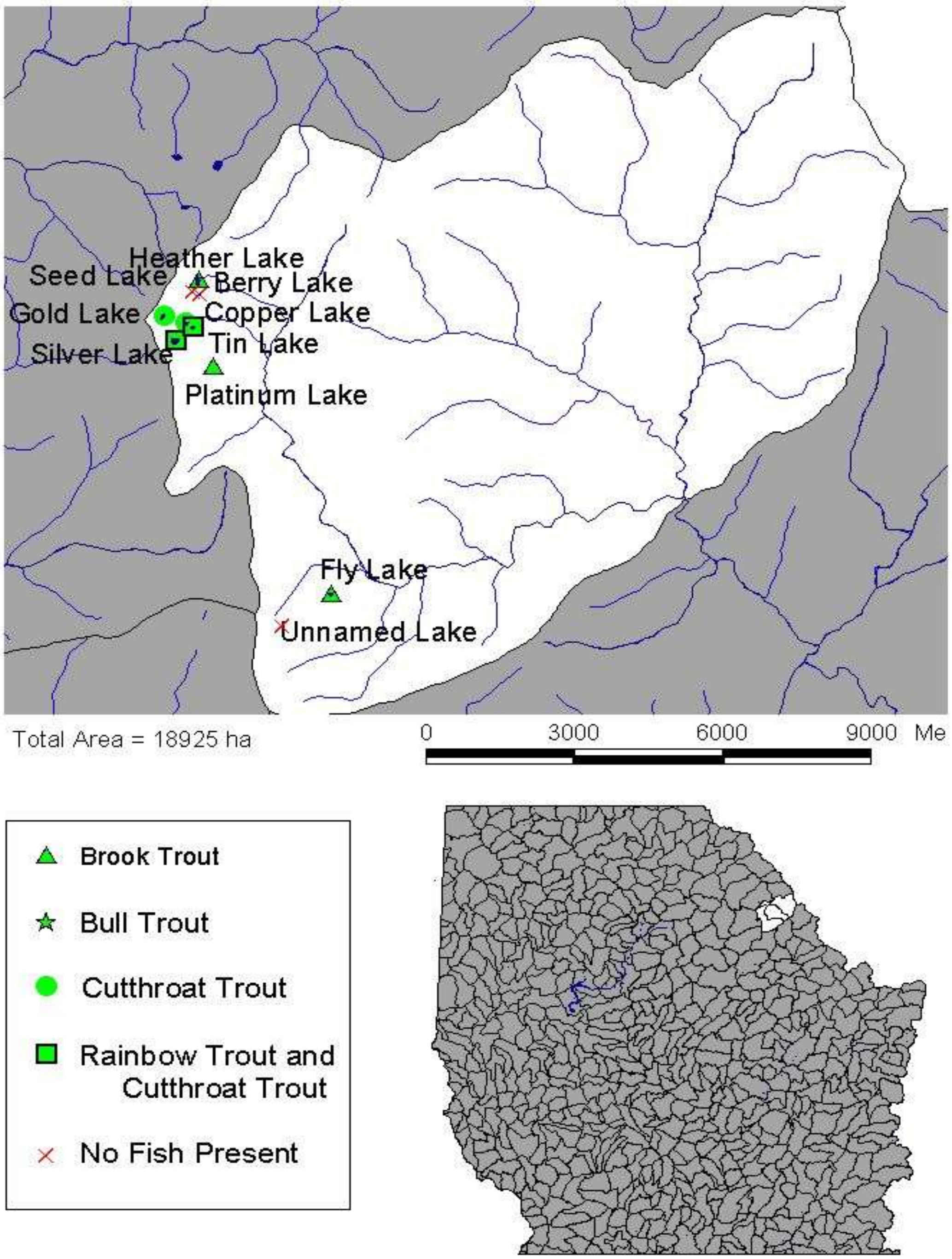
Campsite ID.	Size(m)	Impact	Campsite ID.	Size(m)	Impact
A			C		
B			D		

% of Lake Accessible by Trail ________ Total Distance to Lake from Trailhead (km) ________ Distance Bushwacked (km)

Appendix H. Mountain lake fish management classifications.

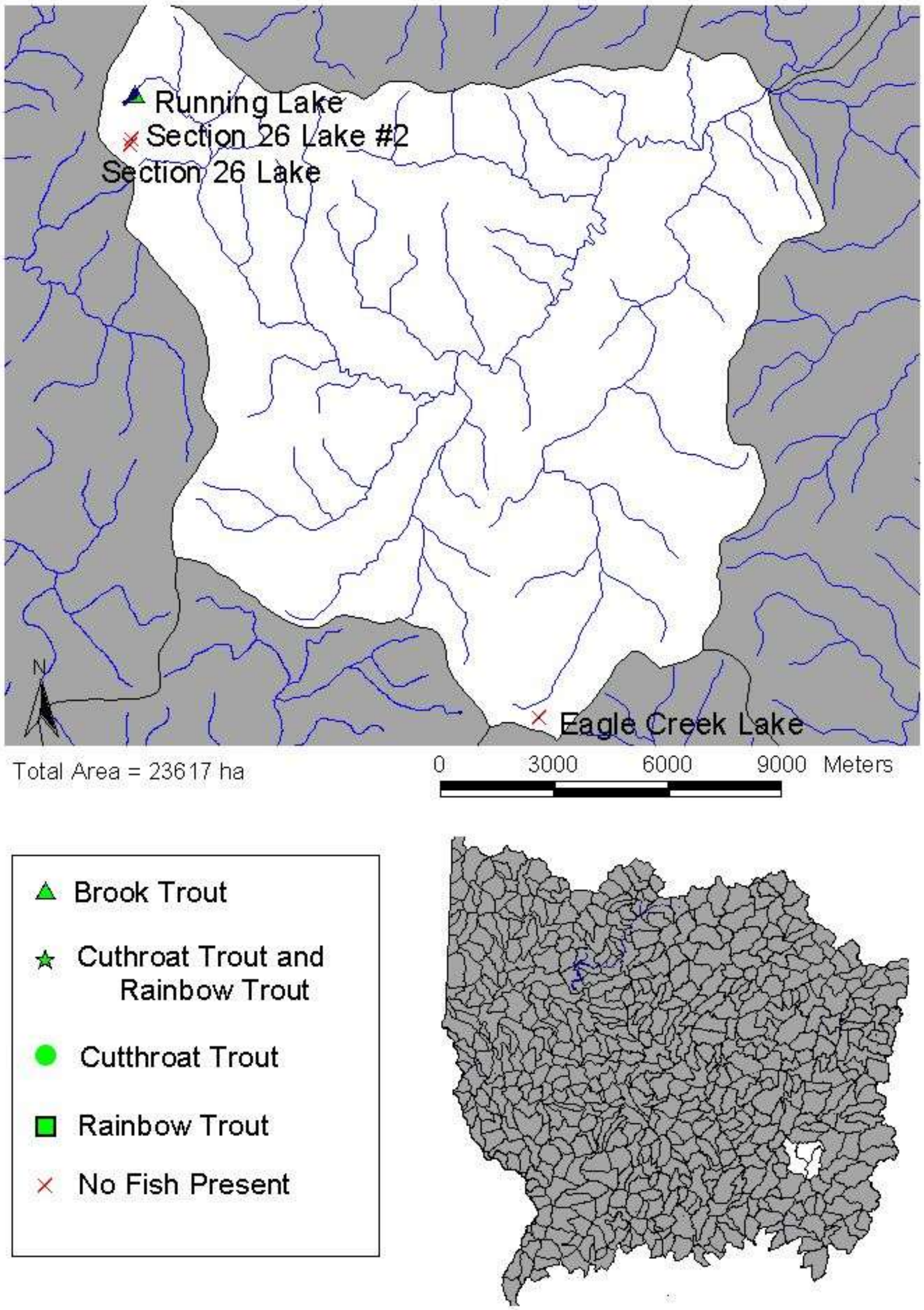
Management classification	Classification meaning
I.A.	Fishless lake with stocking record
I.B.	Fishless lake with no stocking record
II.A.	Fish present with low/moderate natural reproduction
II.B.	Fish present with high level of natural reproduction
III.A.	Native trout lake with possible pure strain
III.B.	Native trout lake - probable hybrids from past stocking
IV.A.	Stockable lake not suitable for further stocking
IV.B.	Stockable lake suitable for further stocking

Appendix I. Locations and fish status of high mountain lakes introduced with tiger muskellunge in the Idaho Fish and Game Clearwater Region during 2006 to suppress or eradicate brook trout.



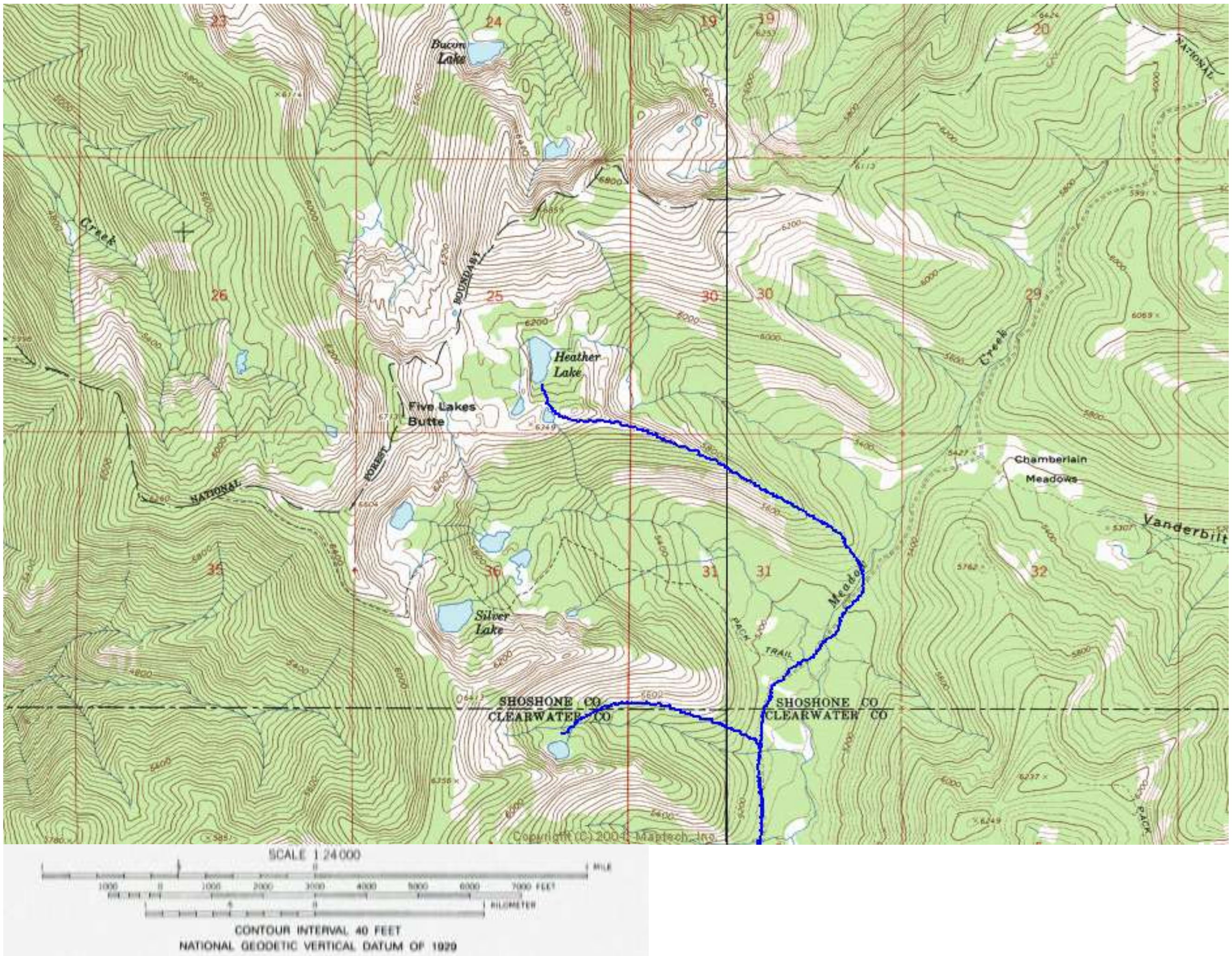
Locations of Fly, Heather and Platinum lakes in the Clearwater National Forest

Appendix I continued.



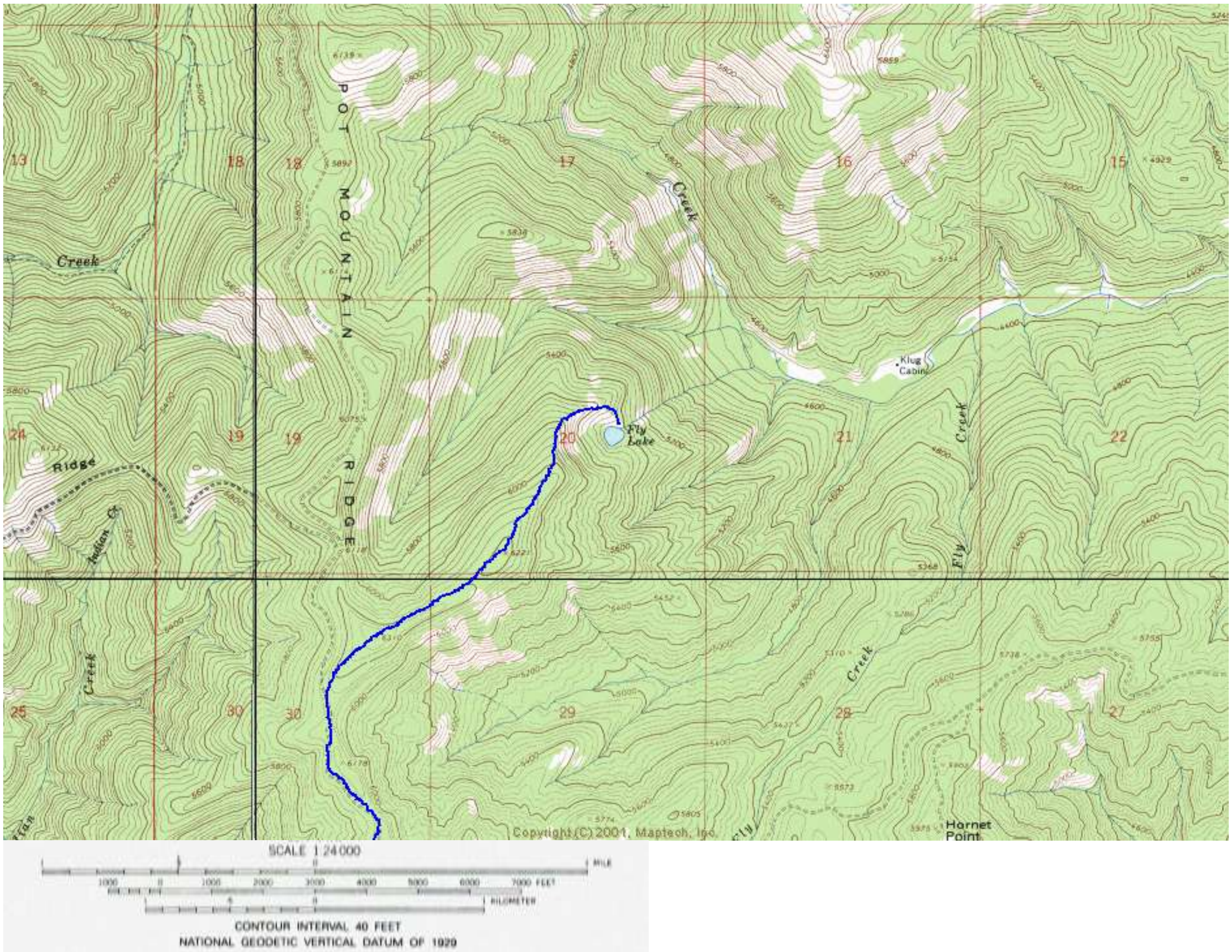
Location of Running Lake in the Nez Perce National Forest

Appendix J. Routes used to access lakes stocked with tiger muskellunge in 2006 in an effort to eradicate brook trout .



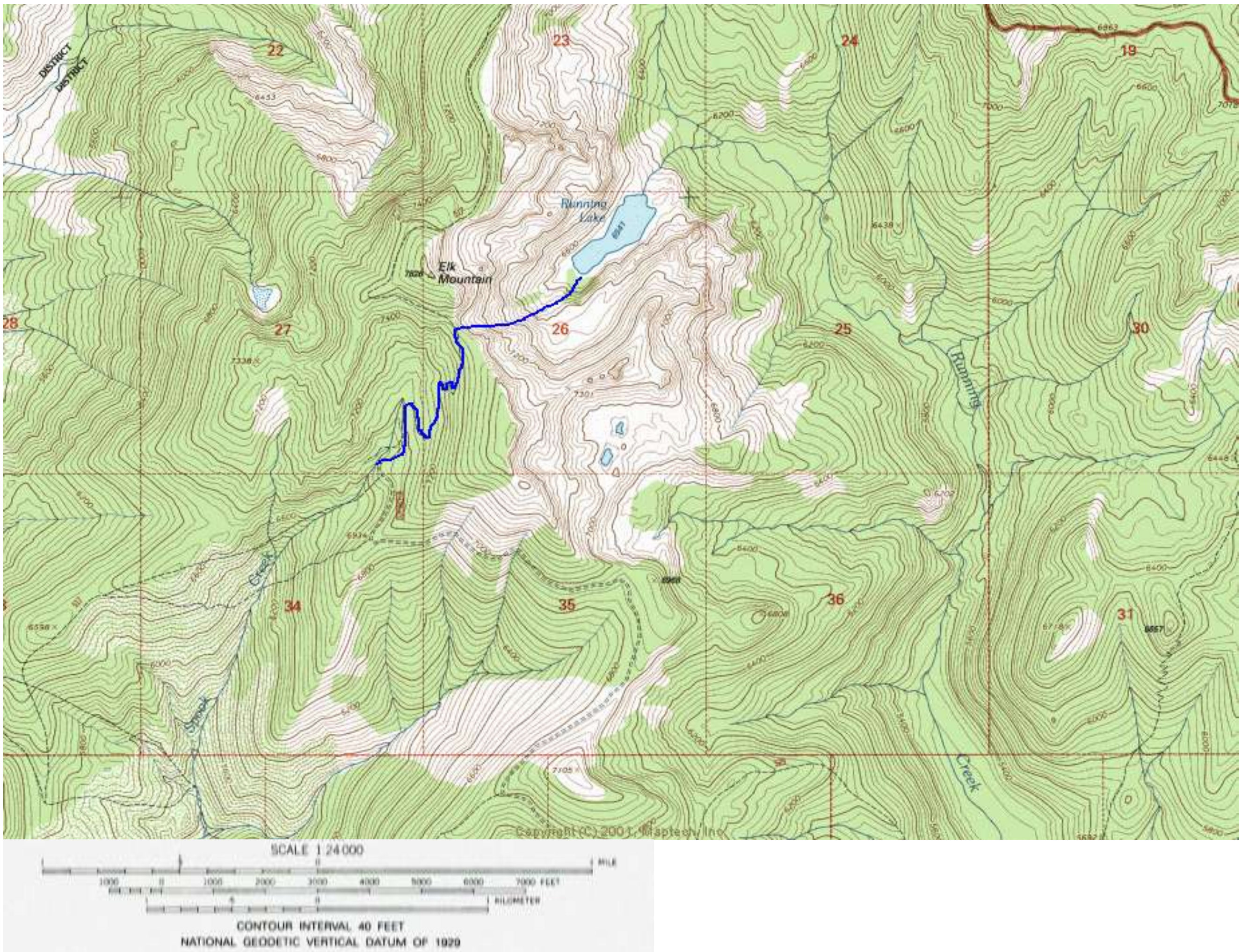
Routes used to access Heather and Platinum Lakes.

Appendix J continued.



Routes used to access Fly Lake.

Appendix J continued.



Routes used to access Running Lake.

Appendix K. Photographs showing lakes and streams surveyed between 2006 and 2009 the Clearwater Region to evaluate the ability of stocked tiger muskellunge to eradicate brook trout.

Fly Lake in the headwaters of the North Fork Clearwater River.

Appendix K continued.

Heather Lake from the headwaters of the North Fork Clearwater River.

Platinum Lake from the headwaters of the North Fork Clearwater River.

Appendix K continued.

Running Lake from the headwaters of the upper Selway River.

Appendix L. Clearwater Region mountain lakes data sheet (page 1) with the physical lake attributes (habitat parameters) section highlighted.

HIGH MOUNTAIN LAKES SURVEY DATA SHEET

Lake Name:	**Survey Date (mm-dd-yy)**
Drainage:	**Legal Description:** Township - Range - Section -
County:	**Elevation (m)**
National Forest – Ranger Distict	**Northing (GPS) -** **Easting (GPS) -**
Crew Members:	**Topo Map (7.5')** **IDFG Lake #**

Lake Description:

HABITAT PARAMETERS

Physical Data	**Chemical Data**
Surface Area (Hectares) -	**Conductivity (μs) -**
Aspect -	**pH -**
Maximum Lake Depth (m) -	**Water Temperature (° C) (shallow) -**
% Bottom Composition < than 3.0 m deep(littoral) -	**Air Temperature (°C) -**
Secchi Disc (m) -	**Weather -**

Littoral zone substrate composition (%)

Bedrock______ Boulders______ Rubble______ Gravel______ Sand______ Silt______ Organic debris______ Logs______

Stream Characteristics

Stream	1	2	3	4	5	6	7
Inlet (I) of Outlet (O)							
Width (m)							
Depth (m)							
Water Speed (1 – 4)							
Dominant Substrate							
Barrier Type							
Distance to Barrier							
% Spawning Sub, (Gr,Sa), 1 – 50 m							
Number of fish observed							

Appendix M. Volumes (acre-ft) of lowland reservoirs in the Clearwater Region, Idaho, at full pool, and one foot intervals.

Depth (feet)	Deer Creek Reservoir	Mann Lake	Soldier's Meadow Reservoir	Spring Valley Reservoir	Tolo Lake	Waha Lake	Winchester Lake
Full Pool	759.608	1,742.673	1,555.465	735.629	247.460	4,307.345	1,500.987
1	684.984	1,637.161	1,437.351	682.750	207.430	4,225.802	1,391.341
2	619.294	1,535.552	1,343.984	633.517	169.148	4,146.400	1,289.321
3	557.859	1,436.852	1,257.392	586.882	132.628	4,068.372	1,193.059
4	499.734	1,340.780	1,176.128	542.277	98.530	3,991.369	1,101.949
5	444.592	1,247.598	1,099.254	499.559	67.592	3,915.242	1,015.613
6	392.520	1,157.483	1,026.107	458.734	41.190	3,839.918	933.759
7	343.465	1,070.515	956.496	419.753	21.157	3,765.317	855.800
8	297.530	986.745	890.064	382.486	8.385	3,691.379	781.297
9	254.570	905.852	826.506	346.878	2.761	3,618.060	710.176
10	214.323	827.989	765.812	312.753	0.678	3,545.328	642.669
11	176.469	753.476	707.852	280.128	0.088	3,473.161	578.802
12	140.952	682.728	652.544	249.172	0.003	3,401.546	518.663
13	107.814	616.280	600.838	219.872		3,330.469	462.239
14	76.748	554.597	552.224	192.318		3,259.917	409.471
15	47.856	496.704	506.100	166.558		3,189.884	360.197
16	20.871	442.700	462.507	142.981		3,120.369	314.365
17	18.359	393.351	421.556	121.635		3,051.362	272.404
18	16.030	348.685	382.961	102.493		2,982.853	233.850
19	13.872	307.738	346.634	85.500		2,914.847	198.162
20	11.907	269.779	312.480	70.349		2,847.339	165.023
21	10.117	234.544	280.193	56.881		2,780.284	134.814
22	8.487	201.943	249.646	44.801		2,713.679	107.376
23	6.995	172.090	220.778	34.398		2,647.526	82.753
24	5.663	145.123	193.436	25.583		2,581.832	61.126
25	4.465	121.154	167.746	18.309		2,516.597	42.618
26	3.387	99.737	143.592	12.560		2,451.824	27.409
27	2.461	80.863	120.985	8.087		2,387.516	16.313
28	1.683	64.395	99.856	4.533		2,323.686	9.129
29	1.050	50.252	80.310	2.005		2,260.343	5.247
30	0.608	38.255	63.162	0.741		2,197.497	2.768
31	0.340	28.241	48.330	0.257		2,135.153	1.109
32	0.188	20.152	35.576	0.079		2,073.309	0.498
33	0.094	13.694	24.965	0.009		2,011.972	0.312
34	0.047	8.694	16.614	<0.001		1,951.158	0.175
35	0.018	4.950	10.697			1,890.871	0.091
36	0.002	2.237	6.387			1,831.156	0.042
37	<0.001	0.586	3.418			1,772.043	0.010
38		0.001	1.441			1,713.503	
39			0.437			1,655.534	
40						1,598.156	
41						1,541.413	
42						1,485.371	
43						1,430.060	
44						1,375.422	
45						1,321.482	

Appendix M (con). Volumes (acre-ft) of lowland reservoirs in the Clearwater Region, Idaho, at full pool, and one foot intervals.

Depth (feet)	Deer Creek Reservoir	Mann Lake	Soldier's Meadow Reservoir	Spring Valley Reservoir	Tolo Lake	Waha Lake	Winchester Lake
46						1,268.273	
47						1,215.740	
48						1,163.989	
49						1,113.117	
50						1,063.248	
51						1,014.299	
52						966.229	
53						919.073	
54						872.840	
55						827.606	
56						783.577	
57						740.557	
58						698.345	
59						656.888	
60						616.195	
61						576.364	
62						537.344	
63						499.189	
64						461.890	
65						425.458	
66						389.964	
67						355.476	
68						322.092	
69						289.887	
70						258.922	
71						229.316	
72						201.252	
73						175.008	
74						150.888	
75						128.941	
76						109.416	
77						92.308	
78						77.323	
79						64.255	
80						52.810	
81						42.828	
82						34.135	
83						26.562	
84						20.009	
85						14.331	
86						9.537	
87						5.670	
88						2.671	
89						0.665	

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